Project Title: WO # Date:

Project Cost ($)	26,705,000	Total cost of project including material and labor in current dollars
Salvage Value of Old Equipment ($)		Salvage value of existing equipment that will be removed.
Total Coal Savings (Ton/yr)	110,000	List the tons of coal that will be saved annually as a result of the project.
Total Fuel Oil Savings (Gal./yr)		List the gallons of fuel oil that will be saved annually as a result of the project.
Power Savings (MWhr)		List the annual auxillary power savings that will result from the project.
Other Savings ($)	0	List the annual savings that will result such as maintenance savings.
Annual Costs With the new Equipment ($)		List the annual costs associated with the new equipment such as maintenance costs.
Future Salvage Value New Equipment($)		List the expected salvage value of the new equipment at the end of the project life.
Project Life (Years)	5	

Total Coal Cost ($/Ton)	25.13
Total Fuel Oil Cost ($/Gal)	0.74
Replacement Power Cost ($/MWhr)	25
Cost of Money (%)	6.04
O&M Escalation (%)	3

Present Value of Project	($15,073,423)
Benefit/Cost Ratio	0.44
Payback Period	9.7
Rate of Return	**-17%**

Notes and Assumptions:

Prepared by:

IP7_036791

Project Cost	26705000
Monthly Payment	2764300
Inflation (%)	3
Cost of Money (%)	6.04
Periods (Years)	5

Project Cost	-26705000.00		
1	2764300.00		
2	2847229.00		
3	2932645.87	Rate of Return	-17%
4	3020625.25	Net Present Value	($15,073,422.69)
5	3111244.00	Payback Period	9.66
		Annuity PV	($11,631,577.31)

Riley Power
Service Contract 45576

		Payments		Contract Running Total
Contract Amount				**$ 8,589,769.00**
Release #1	$ 4,264,884.50		$ 4,264,884.50	
Pay Authorization #2		1,313,744.00	2,951,140.50	7,276,025.00
Pay Authorization #6		2,529,446.00	421,694.50	4,746,579.00
Pay Authorization #7		514,170.00	(92,475.50)	4,232,409.00
Release #3	$ 50,000.00		$ 50,000.00	
Pay Authorization #16		50,000.00	$ -	4,182,409.00
Release # 4	$ 20,000.00		$ 20,000.00	
Pay Authorization #19		20,000.00	$ -	4,162,409.00
Release # 5	$ 20,000.00		$ 20,000.00	
Pay Authorization #20		20,000.00	$ -	4,142,409.00
Release # 8	$ 4,172,408.00		$ 4,172,408.00	
Pay Authorization #9		417,240.80	$ 3,755,167.20	3,725,168.20
Pay Authorization #10		1,460,342.80	$ 2,294,824.40	2,264,825.40
Pay Authorization #14		1,877,583.60	$ 417,240.80	387,241.80
Pay Authorization #15		417,240.80	$ -	(29,999.00)
Release # 11	$ 1,300.00		$ 1,300.00	
Pay Authorization #17		1,300.00	$ -	(31,299.00)
Release # 12	$ 7,542.08		$ 7,542.08	
Pay Authorization #21		7,542.08	$ -	(38,841.08)
Release # 13	$ 3,543.92		$ 3,543.92	
Pay Authorization #18		3,543.92	$ -	(42,385.00)
Release # **NEW**	$ 53,776.10		$ 53,776.10	
Pay Authorization # **NEW**		53,776.10	$ -	**(96,161.10)**
		$ 8,685,930.10		

Unit 1 OFA	Should have been $4,357,360.00 (original bid from Babcock Borsig)
Invoice 6268-1	
Invoice 6387-3	
Invoice 6570-5	
Unit 1 early completion	
Unit 1 T&M Work	
Unit 1 T&M Work	
Unit 2 OFA	
9th Floor Platform	
T&M for pups	
T&M for pups	

INTERMOUNTAIN POWER SERVICE CORPORATION

☒ REQUISITION FOR CAPITAL EQUIPMENT

☐ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Increase Service Contract 45576 (to Babcock Borsig, aka Riley Power for Over-fired Air Modification to both Units).

Date:	
Req./PA No:	214873
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Riley Power Inc.
Box 15040
Worcester, MA 01815-0040

Account No. Service Contract 45576
Work Order No.
Project No.

Qty	Unit	Description: Noun / Adjective / Catalog # / Seller or Manufacturer	Unit Cost	Extension
2	Ea	Contract Increase to cover early-completion	$50,000.00	$100,000.00
		incentive payments for each unit.		
		TOTAL ESTIMATED COST		$100,000.00

Remarks: The contract made provisions for an early-completion incentive of $50,000 for each of the Unit 1 and Unit 2 OFA modifications. These payments were not included in original bids and so were not included in the original Contract Amount when it was set up. These payments were earned and the invoices must be payed.

Delivery requested by [Date] 08-08-05 Originator Dean E. Wood

Dept. Mgr/Supt.	Date	Station Manager	Date	Operating Agent	Date

INTERMOUNTAIN POWER SERVICE CORPORATION

☒ REQUISITION FOR CAPITAL EQUIPMENT

☐ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Boiler modifications associated with the Unit 1 & 2 uprates.

Date: 7/9/02	
Req./PA No: 181199	
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Bid

Account No. 1SGX-402

Work Order No. 02-60456

Project No. IGS02-14

Qty	Unit	Description: Noun / Adjective / Catalog # / Seller or Manufacturer	Unit Cost	Extension
1	job	Modifications, boiler uprate, to include	$3,750,000.00	$7,500,000.00
		engineering, procurement, fabrication,		
		installation, testing and startup in accordance		
		with the attached specifications for Units 1 & 2.		
		Pricing to be provided on a per unit basis for		
		each area of the project scope as outlined in the		
		enclosed pricing sheet. The estimate noted on		
		this requisition is the total associated with the		
		largest possible contract work scope. As noted		
		within the contract, each work scope item shall		
		be quoted for line item award or in combination		
		as deemed appropriate by the Owner.		
		TOTAL ESTIMATED COST		$7,500,000.00

Remarks: Estimated schedule for completion of design, procurement, fabrication and delivery in preparation for the upcoming Unit 1 outage requires that this package be awarded by Aug 1, 2002.

Delivery requested by [Date] 9/1/02 Originator James Nelson

Dept. Mgr/Supt. Date Station Manager Date Operating Agent Date

IP7_036796

GE Energy and Environmental Research Corporation
Recent Construction/Retrofit Experience, including Boiler Performance Analysis

Company	Unit	Application	Unit Size (MW)	Fuel	Base NOx	Final NOx	NOx Reduction	Year	Contact Name	Telephone No.	Modelling Performed?
PEPCO	Chalk Point #1	Gas Reburning Wall	350	Eastern Bituminous	0.80 lb/MMBtu	In Progress	In Progress	2000	Merwin Jones		Yes, prior to retrofit
PEPCO	Chalk Point #2	Gas Reburning Wall	350	Eastern Bituminous	0.80 lb/MMBtu	In Progress	In Progress	2000	Merwin Jones	301 967-5341	Yes, prior to retrofit
Dynegy	Havana #6	Babcock & Wilcox B&W Dual Register	490	Bituminous	0.38 lb/MMBtu	0.24 lb/MMBtu	37%	2000	Mike Keckritz	217-872-3557	Yes, post-retrofit analysis in progress
Tennessee Valley Authority	Allen #2	Overfire Air (Future Reburn)	300	Western Bituminous & PRB	1.2 lb/MMBtu	0.85 lb/MMBtu	29%	1999	Courtney Walton	423 751-6351	Yes, prior to retrofit
Tennessee Valley Authority	Allen #3	Overfire Air (Future Reburn)	300	Western Bituminous & PRB	1.2 lb/MMBtu	0.85 lb/MMBtu	29%	1999	Courtney Walton	423 751-6351	Yes, prior to retrofit
AMP-Ohio	Gorsuch #1	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	Yes, post-retrofit
AMP-Ohio	Gorsuch #2	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	Yes, post-retrofit
AMP-Ohio	Gorsuch #3	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	Yes, post-retrofit
AMP-Ohio	Gorsuch #4	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	Yes, post-retrofit
Baltimore Gas and Electric	CP Crane #1	Gas Reburning Cyclone	200	Bituminous	1.5 lb/MMBtu	0.60-0.52 lb/MMBtu	60-65%	1999	Harry Brocato	410 787-5088	Yes, prior to retrofit
Baltimore Gas and Electric	CP Crane #2	Gas Reburning Cyclone	200	Bituminous	1.5 lb/MMBtu	0.60-0.52 lb/MMBtu	60-65%	1999	Harry Brocato	410 787-5088	Yes, prior to retrofit
Conectiv	Edge Moor #4	Gas Reburning Tangential	160	Bituminous	0.32 lb/MMBtu	0.16 lb/MMBtu	48%	1999	Mike Maziarz	302 283-5720	Yes, prior to retrofit
Allegheny	Hatfield #2	Gas Reburning Wall	600	Bituminous	0.60 lb/MMBtu	In Progress		1999	Mark Scaccia	724 838-6507	Yes, prior to retrofit
Tennessee Valley Authority	Allen #1	Gas Reburning Cyclone	300	Western Bituminous & PRB	1.2 lb/MMBtu	0.42 lb/MMBtu	65%	1998	Courtney Walton	423 751-6351	Yes, prior to retrofit
Illinois Power	Hennepin #1	Orimulsion Reburning w/OFA, T-Fired	71	Eastern Bituminous	0.75 lb/MMBtu	0.26 lb/MMBtu	65%	1997	Jim Cumbow	815 339-9266	Yes, prior to retrofit
New York State Electric and Gas	Greenidge #6	Gas Reburning Tangential (LNCFS)	100	Eastern Bituminous	0.625 lb/MMBtu	0.28 lb/MMBtu	55%	1996	Ed Thomas	607 762-8695	Yes, prior to retrofit
Gas Research Institute / New York State Electric and Gas	Greenidge #6	Advanced Gas Reburning Tangential w/ Gas Reburning	100	Eastern Bituminous	0.625 lb/MMBtu	0.15 lb/MMBtu Predicted	76%	1996	Ed Thomas	607 762-8695	Yes, prior to retrofit
Eastman Kodak	Kodak Park #16	Micronized Coal Reburning Cyclone	50	Bituminous	1.20 lb/MMBtu	0.60 lb/MMBtu	50%	1996	Bob Rock	716 588-7619	Yes, prior to retrofit
Public Service of Colorado	Cherokee #3	Low NOx Burners (FW) Gas Reburning system w/OFA Incl Flame Safe System Design Mods Wall Fired	171	Western Bituminous	0.73 lb/MMBtu	0.26 lb/MMBtu	64%	1992	Eric Rindahl	303 571-7949	Yes, prior to retrofit
City Water, Light & Power	Lakeside #7	Gas Reburning system w/OFA Incl. Flame Safe System Design Mods. Cyclone Fired	33	Eastern Bituminous	0.95 lb/MMBtu	0.32 lb/MMBtu	66%	1992	Tom Booker	217 786-3957	Yes, prior to retrofit
Illinois Power	Hennepin	Gas Reburning System	71	Eastern	0.75	0.25	67%	1990	Jim Cumbow	815 339-9266	

Babcock & Wilcox Company
a McDermott company

20 S. Van Buren Avenue
P.O. Box 351
Barberton, OH 44203-0351
(330) 753-4511

June 7, 2002

INTERMOUNTAIN POWER
850 W. Brush Wellman Road
Delta, Utah 84624-9546

Attention: Mr. James Nelson

Re: Capacity Increase / Low NOx
Subj: Budgetary Pricing
B&W Proposal P-003111

Dear Mr. Nelson:

B&W is pleased to offer the following budgetary pricing for materials and installation to increase capacity and also to reduce NOx for Intermountain Power Station Unit #1, B&W Boiler RB-614.

Scope of Supply

Item 1 Overfire Air System (Phase 1)

1.1 Windbox NOx compartment (installed on top of existing front and rear windboxes) to be designed for present and future NOx ports including:
Platework with expansion folds and attachment hardware.
Feeder ductwork with expansion joints and air monitors.
Supports for feeder ductwork.

1.2 Water wall panel insert openings for 6 to 7 NOx ports Including:
1 panel insert (opening) for each NOx port.
Membrane tube construction will be the same as present furnace walls.

1.3 Total of 6 to 7 Dual Air Zone NOx Port registers including:
Supports between windbox and wall tubes.
Pitot tube.
2 thermocouples per port.
Automatic sliding air damper.
Initial adjustment and calibration of NOx ports.
Operating Instruction Manuals.

1.4 Total of 48 perforated plate shrouds to restrict air flow at existing Dual Register Burners.

1.5 Engineering and Project Management.

1.6 Freight to job-site.

1.7 Removal of all front and rear sootblowers at elevation 4806"-11". Any remaining holes will be plugged by B&W Construction.

Item 2 Platen SH extensions

2.1 Increase lower portion of existing Platen SH by approximately 8'. Existing SH Platens will be cut approximately 2' above the existing inside loops. New extended partial lower loops will be field welded to the existing elements and shall each include new crossover tubes and ties. There are 16 front loop sections and 16 rear loop sections for a total of 32 partial loop section extensions. Crossover ties will be partially shop attached and partially field attached. Tube materials will be SA213T22 and SA213TP347H. B&W current design split ring castings will be used for alignment at the lowest elevation.

Not Included

1. Support collector steel or support rods if required for Platen SH.
2. Engineering review of metals (for Platen SH or outlet header).
3. Modifications to the existing burner control system.
4. Burner modifications (other than mentioned above).
5. Control modifications or field wiring.
6. New sootblowers or relocation of sootblowers.
7. Support steel or platforms for access to the NOx ports outside of the boiler.
8. Performance Guarantees or testing (pre or post).
9. Tuning or testing equipment.
10. B&W Field Engineering Service.
11. Bonding Costs
12. Sales or Use Taxes

Predicted Performance

The furnace platen extension is offered as a means of increasing the total superheater absorption by allowing some degradation in furnace cleanliness while maintaining a constant furnace exit gas temperature. In effect, the platen absorption increases with the greater surface and higher gas temperature entering the platens while holding FEGT. The expected performance of the superheater and platens has been based on a total excess air leaving the economizer of 20% or 18% to the combustion equipment. This is a 2 point increase from the original design and is a result of the expected addition of an OFA system. The nominal 8' platen extension will allow the gas temperature entering the platens to increase by approximately 35F while maintaining a constant furnace exit gas temperature. Under these conditions, the superheater absorption will increase by about 2.5% or an increase in spray will occur by approximately 80 to 100mlb/hr (an equivalent superheater spray down of 6F) if the base condition is a 1005 F steam temperature with no spray. It is important to note that the basis of the superheater performance increase is the ability to increase the gas temperature entering the platens. For a constant furnace cleanliness condition, the platens will provide no measurable change in superheater or reheater performance. While the overall secondary superheater inlet bank cleanliness is not expected to change as long as the FEGT is held constant, there may be somewhat increased cleaning required of the lowest section of the this bank as the FEGT is increased to improve superheater performance.

Based on a current NOx emission rate of 0.4 to 0.45 LBS/ million BTU, we would predict that the OFA system will reduce NOx to below 0.4 LBS / million BTU. CO and LOI will definitely increase. As this is a "partial" OFA system, we have no way (no operational experience) to predict performance impact to these items.

Budgetary Pricing and Progress Payment Schedule (1 unit only)

Budgetary OFA and SH Platen – Materials $ 1,200,000

Budgetary OFA and SH Platen – Installation * $ 2,300,000 - $ 2,900,000
* We are still working on this price.

Payments:

% Of Price	Milestone
50% of material	Receipt of Raw Mat'l at Shop
50% of material	Shipment Complete On-Site
50% of installation	Installation Mid-point
50% of installation	Installation Complete

Delivery and Installation

Delivery on-site for items 1 and 2 as described above is approximately 7 months after receipt of acceptable order. Installation time will require approximately 5 weeks not including mobilization or de-mobilization time.

Commercial Terms and Conditions

This proposal is predicated upon the application of B&W Standard Terms and Conditions.

Technical Conditions

This proposal is based on design and manufacturing in accordance with ASME Boiler and Pressure Vessel Code along with B&W technical design and manufacturing standards, which shall form the technical basis of a resulting contract.

We look forward to your favorable evaluation of this budgetary proposal and appreciate the opportunity to be of service to Intermountain Power. Please feel free to contact us if you require additional information.

Very truly yours,

BABCOCK & WILCOX COMPANY

Roger J. Kleisley
Regional Project Manager

cc: M. A. Costanzo – Barberton Service Projects
J. S. Metzger – Barberton Service Projects
G. S. Bernstein – Denver Sales
J. B. Doyle – Denver Sales
R. W. Wewer – Denver Service
W. A. Willman – BWCC Denver

GE Energy and Environmental Research Corporation
Recent Construction/Retrofit Experience

Company	Unit	Application	Unit Size (MW)	Fuel	Base NOx	Final NOx	NOx Reduction	Year	Contact Name	Telephone No.	Turnkey
Illinois Power	Hennepin #1	Gas Reburning System w/OFA Incl. Flame Safe System Design Mods. T-Fired	71	Eastern Bituminous	0.75 lb/MMBtu	0.25 lb/MMBtu	67%	1990	Jim Cumbow	815 339-9266	yes
City of Columbus	Columbus Ohio	Gas Cofiring, Burner & Flame Safety Design & Installation	20	RFD	NA	NA	NA	1992	Tom Scothorn	614 645-3147	
Public Service of Colorado	Cherokee #3	Low NOx Burners (FW) Gas Reburning system w/OFA Incl. Flame Safe System Design Mods. Wall Fired	171	Western Bituminous	0.73 lb/MMBtu	0.26 lb/MMBtu	64%	1992	Eric Rindahl	303 571-7949	yes
City Water, Light & Power	Lakeside #7	Gas Reburning system w/OFA Incl. Flame Safe System Design Mods. Cyclone Fired	33	Eastern Bituminous	0.95 lb/MMBtu	0.32 lb/MMBtu	66%	1992	Tom Booker	217 786-3957	yes
New York State Electric and Gas	Greenidge #6	Gas Reburning Tangential (LNCFS)	100	Eastern Bituminous	0.625 lb/MMBtu	0.28 lb/MMBtu	55%	1996	Ed Thomas	607 762-8695	
Gas Research Institute / New York State Electric and Gas	Greenidge #6	Advanced Gas Reburning Tangential w/ Gas Reburning	100	Eastern Bituminous	0.625 lb/MMBtu	0.15 lb/MMBtu Predicted	76%	1996	Ed Thomas	607 762-8695	
Eastman Kodak	Kodak Park #16	Micronized Coal Reburning Cyclone	50	Bituminous	1.20 lb/MMBtu	0.60 lb/MMBtu	50%	1996	Bob Rock	716 588-7619	
Illinois Power	Hennepin #1	Orimulsion Reburning w/OFA, T-Fired	71	Eastern Bituminous	0.75 lb/MMBtu	0.26 lb/MMBtu	65%	1997	Jim Cumbow	815 339-9266	
Conectiv	Indian River #1	Low NOx Burner Modifications and Overfire Air	89	Bituminous	0.67 lb/MMBtu	0.38 lb/MMBtu	43%	1998	Joe Colla	302 283-5710	

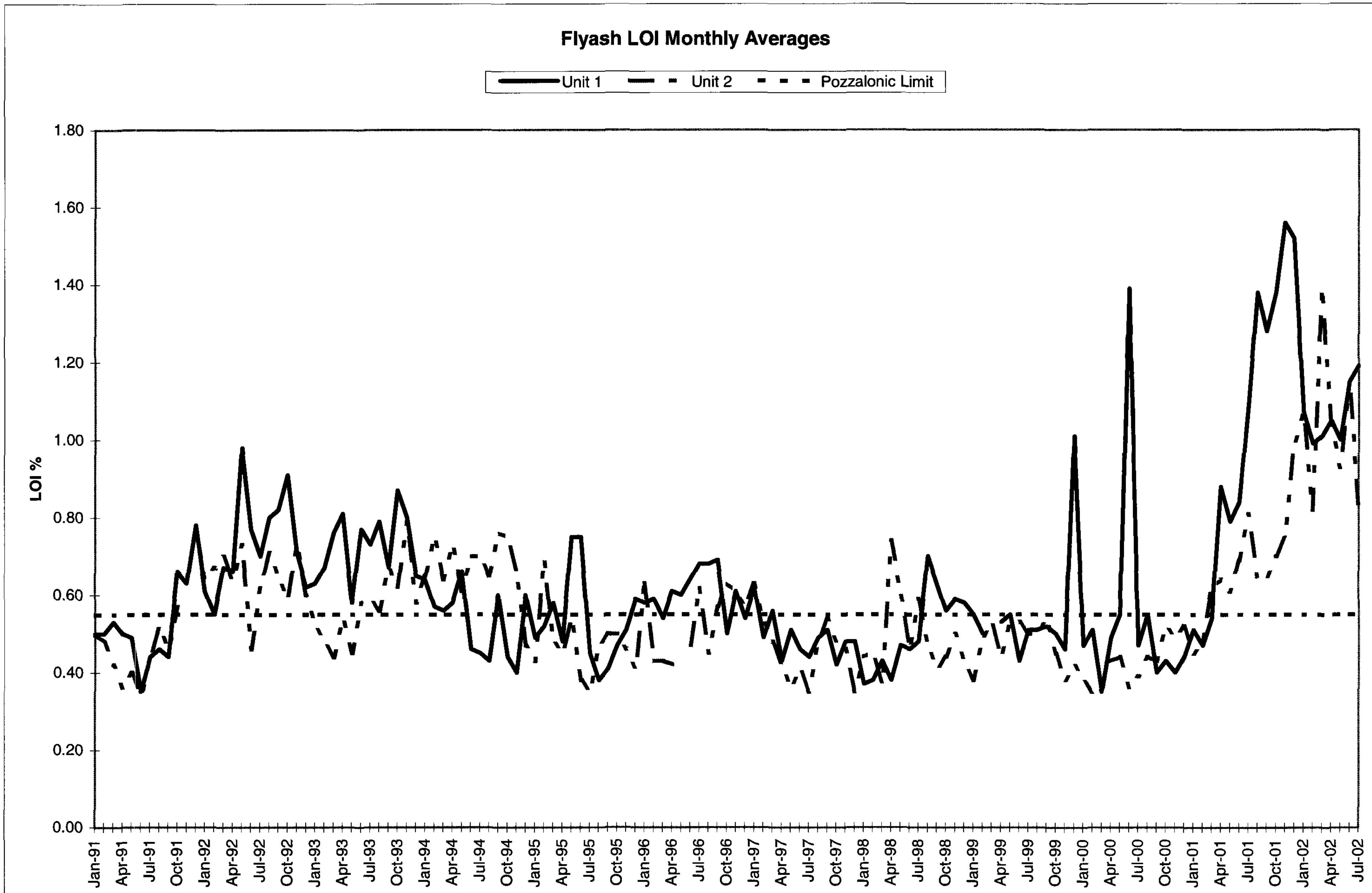
GE Energy and Environmental Research Corporation
Recent Construction/Retrofit Experience

Company	Unit	Application	Unit Size (MW)	Fuel	Base NOx	Final NOx	NOx Reduction	Year	Contact Name	Telephone No.	Turnkey
Conectiv	Indian River #2	Low NOx Burner Modifications and Overfire Air	89	Bituminous	0.81 lb/MMBtu	0.38 lb/MMBtu	53%	1998	Joe Colla	302 283-5710	
Tennessee Valley Authority	Allen #1	Gas Reburning Cyclone	300	Western Bituminous & PRB	1.2 lb/MMBtu	0.42 lb/MMBtu	65%	1998	Courtney Walton	423 751-6351	
Tennessee Valley Authority	Allen #2	Overfire Air (Future Reburn)	300	Western Bituminous & PRB	1.2 lb/MMBtu	0.85 lb/MMBtu	29%	1999	Courtney Walton	423 751-6351	
Tennessee Valley Authority	Allen #3	Overfire Air (Future Reburn)	300	Western Bituminous & PRB	1.2 lb/MMBtu	0.85 lb/MMBtu	29%	1999	Courtney Walton	423 751-6351	
AMP-Ohio	Gorsuch #1	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	
AMP-Ohio	Gorsuch #2	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	
AMP-Ohio	Gorsuch #3	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	
AMP-Ohio	Gorsuch #4	Low NOx Burners Overfire Air	51	Bituminous	0.90 lb/MMBtu	0.43 lb/MMBtu	52%	1999	Steve Brown	740 374-8913 x126	
Baltimore Gas and Electric	CP Crane #1	Gas Reburning Cyclone	200	Bituminous	1.5 lb/MMBtu	0.60-0.52 lb/MMBtu	60-65%	1999	Harry Brocato	410 787-5088	
Baltimore Gas and Electric	CP Crane #2	Gas Reburning Cyclone	200	Bituminous	1.5 lb/MMBtu	0.60-0.52 lb/MMBtu	60-65%	1999	Harry Brocato	410 787-5088	
Conectiv	Edge Moor #4	Gas Reburning Tangential	160	Bituminous	0.32 lb/MMBtu	0.16 lb/MMBtu	48%	1999	Mike Maziarz	302 283-5720	

GE Energy and Environmental Research Corporation
Recent Construction/Retrofit Experience

Company	Unit	Application	Unit Size (MW)	Fuel	Base NOx	Final NOx	NOx Reduction	Year	Contact Name	Telephone No.	Turnkey
Allegheny	Hatfield #2	Gas Reburning Wall	600	Bituminous	0.60 lb/MMBtu	In Progress		1999	Mark Scaccia	724 838-6507	
PEPCO	Chalk Point #1	Gas Reburning Wall	350	Eastern Bituminous	0.80 lb/MMBtu	In Progress		2000	Merwin Jones		
PEPCO	Chalk Point #2	Gas Reburning Wall	350	Eastern Bituminous	0.80 lb/MMBtu	In Progress		2000	Merwin Jones	301 967-5341	
Dynegy	Havana #6	Babcock & Wilcox B&W Dual Register	490	Bituminous	0.38 lb/MMBtu	0.24 lb/MMBtu	37%	2000	Mike Keckritz	217-872-3557	
Michigan State Univ.	#3	Low NOx Burners & Overfire	30	Bituminous	0.70 lb/MMBtu	0.38 lb/MMBtu	45%	2002	Rick Johnson	517-355-3314	yes

OFA Total 4278



Flyash LOI Monthly Averages
Unit 1
Unit 2
Pozzalonic Limit
LOI %
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
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Jan-91
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Apr-02
Jul-02

IP7_036805

From: "Metzger, John S" <jsmetzger@babcock.com>
To: <jim-n@ipsc.com>
Date: 6/7/02 2:40PM
Subject: Budget Proposal for IPP Low NOx and SH Platens

Jim,
Please see attached.
We will talk to you on Monday to answer any questions.
Regards,
John Metzger
B&W Proposal Manager
<<IPP P-003111 Budget Pricing 6-7-02.doc>>

CC: "Costanzo, Michael A" <macostanzo@babcock.com>, "Kleisley, Roger J" <rjkleisley@babcock.com>, "Bernstein, Gary S" <gsbernstein@babcock.com>, "Doyle, John B" <jbdoyle@babcock.com>, "Wewer, Robert W" <rwwewer@babcock.com>, "Willman, William A" <wawillman@babcock.com>

From: James Nelson
To: Kleisley, Roger J
Date: 8/6/02 3:05PM
Subject: Fwd: IPP Burners

Roger,
Bob's note is almost correct. The one main design change instituted on the Unit 1 burners was the 'segmented backplate'. The Unit 1 burners have a multi-lobe backplate design. 5 or 6 segments as I recall. The clip or restraint design on the back plate is therefore different than the standard DRB burners.

Regards,
James

>>> "Wewer, Robert W" <rwwewer@babcock.com> 08/01/02 10:38PM >>>
Roger,

I did get your voice message.

According to Jim Nelson, the only modifications done to the burners are the flame stabilizers and outer register shrouds on both units. Unit 1 has the split HD registers. Burner nozzleson both units have been changed out with ceramic lined nozzles from the flange to three feet past the conical diffusers as well as a P&I spun cast tip.

By copy to Jim, could you give Roger some more detail on the size and location of the outer register shroud, if you have not done so already?

Thanks,

Bob

From: James Nelson
To: rhessel@bbpwr.com
Date: 5/15/02 2:18PM
Subject: Intermountain Drawings - Part II

Here is the second portion of the drawings.

Regards,

James

From: James Nelson
To: rhessel@bbpwr.com
Date: 5/15/02 2:03PM
Subject: Intermountain Drawings- part I

Roger,
Tom Martinco asked if I would send the core arrangement drawings for our boiler. There will be several other structural, tubing and waterwall type drawings that I intend to send out with the RFQ, but Tom felt it was important to give you an indication of what type of info to expect.

This is the first of two emails I am sending to you. There should be approximately 30 drawings in all. Of course I cannot vouch for the accuracy of these drawings but I think it may provide some good corroboration for the data you have generated.

Call with any questions.

Regards,
James Nelson
(435)864-6464

From: <kdavis@bbpwr.com>
To: <jim-n@ipsc.com>
Date: 9/11/02 1:44PM
Subject: Intermountain Power - BBPI Proposal 50180

Good Afternoon Jim:

Just wanted to drop you an e-mail to confirm our telephone conversation of earlier today regarding T's&C's for the OFA & SH pendant modifications.

As your aware, BBPI received an authorization to proceed accompanied with what looks to be standard boiler plate terms which as you can imagine present some serious issues that we just can't accept. If we were to aacknowledge your authorization to proceed, we'd need to acknowledge it contingent upon the clarifications & exceptions included in our proposal. As a result of my call to you, I realize that you & Roger had been conversing in regard to these issues and were planning to discuss and hopefully come to a resolution on Friday of this week. In general, it sounds like BBPI & IP are pretty close to reaching mutual agreement on terms and conditions.

In the interest of maintaining project schedule, I've authorized our engineering group to proceed with its efforts for up to a (2) week period from this date. If resolution of terms and conditions is not concluded before the September 25th, BBPI will need to suspend work on this project. I believe this should be sufficient time to conclude negotiations.

I appreciate your understanding and cooperation. Roger & Peter will be in contact with you on Friday. Thanks again and have a good day.

Kevin Davis
Manager Proposal Operations
BBPI-Energy Systems & Services
Tel: (508)854-3818
Fax: (50)853-3944

CC: <rhessel@bbpwr.com>, <pricht@bbpwr.com>, <bleblanc@bbpwr.com>, <bfaia@bbpwr.com>

From: <fred.hess@power.alstom.com>
To: <jim-n@ipsc.com>
Date: 5/13/02 5:02PM
Subject: Intermountain Power - PSH and Plat SH modifications

James:
As a follow-up to our telcon last week:

PDE (ALSTOM Performance Design Engineering) has reviewed all the information that we have on the Intermountain B&W boiler(s). We offer the following comments:

The information overall is very complete.
The boiler side elevation drawing is small and difficult to read. A full size print would help a lot.
The test data taken on 1/8/01 9:30-11:30 is very complete. However, only the economizer outlet water temperature is not included in any of the data supplied. This temperature is vital in the process of modeling the boiler performance.

If Intermountain Power could supply the drawing and the economizer outlet water temperature for the above test or a new set of complete data, modeling could get started at any time.

James, please keep in mind that ALSTOM would do this modeling to support our proposal efforts on the pending Primary SH and/or Platen SH modifications. It is not our desire or intent to provide modeling results, conceptual drawings, etc. that could/would be used for competitive bidding purposes by Intermountain. Our Design Engineering exists to support our products and services. We can not/will not provide design engineering of pressure parts for others to fabricate.

Thank you for your inquiry. Please advise if you have any questions, and how you wish to proceed.

Regards,
FRED

CC: <danny.gelbar@power.alstom.com>, <rick.tacy@power.alstom.com>, <john.m.harmon@power.alstom.com>

September 19, 2002

Mr. James Nelson
Intermountain Power Service Corp.
850 W. Brush Wellman Rd.
Delta, Utah 84624-9546

Re: Installation of Boiler Uprate Modifications on Units 1 & 2

Mr. Nelson:

This is to reconfirm TEI Construction's commitment to performing this project with Babcock Borsig Power as we originally proposed.

We are totally committed to this project and working together with BBPI regardless of whether or not there is any type of common ownership and/or inter company relationship between the two companies.

If the project is awarded to BBPI, TEI Construction WILL perform the on site work

We look forward to working with you on this project and if you have any questions or further concerns please feel free to give me a call directly at (864) –879-6860.

Sincerely,
TEI Construction Services, Inc.

Dale Naughton
President

From: "Bernstein, Gary S" <gsbernstein@babcock.com>
To: <JIM-N@ipsc.com>
Date: 8/28/02 2:02PM
Subject: Intermountain Power Service Company IPSC Specification No. 45576 B&W Proposal No. P-003111

Jim,

Pursuant to our tele. call this morning, I would like to offer the following:

1. B&W's position on the Terms and Conditions offered in our proposal are subject to negotiation. Please advise those terms presented by B&W that are "show-stoppers" on your side. As with the technical discussions we had last week, we would request that commercial discussions be held as well. As I stated to you, I know we can come to terms that are suitable for both our companies with a risk profile is fair and reasonable for both companies.

2. I would like to point out that our NOx guarantee is a 15% reduction from a base-line test. B&W did not place any minimum "setpoint" on that baseline test. I believe that this is a positive aspect. If needed, we could assign a value knowing that IPSC is now focusing on a full complement of OFA ports.

3. Our proposal based on IPSC's request was based on IPSC choosing and selecting various scopes of supply. Our proposal and commercial terms selected was based on a menu of options. You advised today that the "TOTAL" scope will be the basis of the project which will include the platens, a complete OFA system, and scaffolding. The value of this work from B&W's proposal is about $4.5M per unit. Based on the size of this project, we can understand that the risk profile can change vs. a $800,000 material order for the OFA ports. As mentioned in (1) above, we can discuss in further detail commercial issues that would satisfy both B&W and IPSC risk profiles.

4. I would like to point out the B&W's experience in the area of low NOx burners and OFA systems is beyond compare. Our competition does not have as strong as an experience and success list for units of IPSC's size. Though our competition may have also commented negatively about our company in the past, B&W's financial strength has been very strong since entering C-11 proceedings over 2 1/2 years ago. We have appreciated unsurpassed customer loyalty during this period, and as a result, we have been able to significantly grow our business volume, generate superior financial results, invest in upgrading our business infrastructure and corecapabilities, resolve pre-existing commercial risks and retain the critical skills necessary to execute all of the services that our customers count on us to provide.

5. We continue to discuss modeling. I don't want this to be a technical showstopper as well. If there are additional cases that IPSC would like B&W to run, we can do that and include as part of our scope of supply.

6. You have identified to me in numerous discussions the value of the OEM's experience. I believe that as the OEM we can bring to you the best solution as compared to our competition.

Roger Kleisley, Rob Tedrow , Bill Willman and I would like to discuss these above points with your team. Please advise a suitable time etc. (recommend a teleconference as soon as possible), or feel free to respond via e-mail.

Regards,

Gary S. Bernstein, P.E.
District Sales Manager
Babcock & Wilcox

CC: <RALPH-N@ipsc.com>, "Tedrow, Robert L" <rltedrow@babcock.com>, "Kleisley, Roger J" <rjkleisley@babcock.com>, "Willman, William A" <wawillman@babcock.com>, <george-c@ipsc.com>

From: Phil Hailes
To: cpenterson@bbpwr.com; rhessel@bbpwr.com; rjkleisley@babcock.com
Date: 8/12/02 4:17PM
Subject: Intermountain Power, Uprate Bid Package LOI Information

Gentlemen,

In response to a request by Craig Penterson (Babcock Borsig Power) , I'm providing you with a plot of our LOI's for both units. This is information is regarding the superheat, over-fire air, etc. bid package.

Phil Hailes

CC: James Nelson

Babcock & Wilcox Company
a McDermott company

20 S. Van Buren Avenue
P.O. Box 351
Barberton, OH 44203-0351
(330) 753-4511

June 7, 2002

INTERMOUNTAIN POWER
850 W. Brush Wellman Road
Delta, Utah 84624-9546

Attention: Mr. James Nelson

Re: Capacity Increase / Low NOx
Subj: Budgetary Pricing
B&W Proposal P-003111

Dear Mr. Nelson:

B&W is pleased to offer the following budgetary pricing for materials and installation to increase capacity and also to reduce NOx for Intermountain Power Station Unit #1, B&W Boiler RB-614.

Scope of Supply

Item 1 Overfire Air System (Phase 1)

1.1 Windbox NOx compartment (installed on top of existing front and rear windboxes) to be designed for present and future NOx ports including:
Platework with expansion folds and attachment hardware.
Feeder ductwork with expansion joints and air monitors.
Supports for feeder ductwork.

1.2 Water wall panel insert openings for 6 to 7 NOx ports Including:
1 panel insert (opening) for each NOx port.
Membrane tube construction will be the same as present furnace walls.

1.3 Total of 6 to 7 Dual Air Zone NOx Port registers including:
Supports between windbox and wall tubes.
Pitot tube.
2 thermocouples per port.
Automatic sliding air damper.
Initial adjustment and calibration of NOx ports.
Operating Instruction Manuals.

1.4 Total of 48 perforated plate shrouds to restrict air flow at existing Dual Register Burners.

1.5 Engineering and Project Management.

1.6 Freight to job-site.

1.7 Removal of all front and rear sootblowers at elevation 4806"-11". Any remaining holes will be plugged by B&W Construction.

Item 2 Platen SH extensions

2.1 Increase lower portion of existing Platen SH by approximately 8'. Existing SH Platens will be cut approximately 2' above the existing inside loops. New extended partial lower loops will be field welded to the existing elements and shall each include new crossover tubes and ties. There are 16 front loop sections and 16 rear loop sections for a total of 32 partial loop section extensions. Crossover ties will be partially shop attached and partially field attached. Tube materials will be SA213T22 and SA213TP347H. B&W current design split ring castings will be used for alignment at the lowest elevation.

Not Included

1. Support collector steel or support rods if required for Platen SH.
2. Engineering review of metals (for Platen SH or outlet header).
3. Modifications to the existing burner control system.
4. Burner modifications (other than mentioned above).
5. Control modifications or field wiring.
6. New sootblowers or relocation of sootblowers.
7. Support steel or platforms for access to the NOx ports outside of the boiler.
8. Performance Guarantees or testing (pre or post).
9. Tuning or testing equipment.
10. B&W Field Engineering Service.
11. Bonding Costs
12. Sales or Use Taxes

Predicted Performance

The furnace platen extension is offered as a means of increasing the total superheater absorption by allowing some degradation in furnace cleanliness while maintaining a constant furnace exit gas temperature. In effect, the platen absorption increases with the greater surface and higher gas temperature entering the platens while holding FEGT. The expected performance of the superheater and platens has been based on a total excess air leaving the economizer of 20% or 18% to the combustion equipment. This is a 2 point increase from the original design and is a result of the expected addition of an OFA system. The nominal 8' platen extension will allow the gas temperature entering the platens to increase by approximately 35F while maintaining a constant furnace exit gas temperature. Under these conditions, the superheater absorption will increase by about 2.5% or an increase in spray will occur by approximately 80 to 100mlb/hr (an equivalent superheater spray down of 6F) if the base condition is a 1005 F steam temperature with no spray. It is important to note that the basis of the superheater performance increase is the ability to increase the gas temperature entering the platens. For a constant furnace cleanliness condition, the platens will provide no measurable change in superheater or reheater performance. While the overall secondary superheater inlet bank cleanliness is not expected to change as long as the FEGT is held constant, there may be somewhat increased cleaning required of the lowest section of the this bank as the FEGT is increased to improve superheater performance.

Based on a current NOx emission rate of 0.4 to 0.45 LBS/ million BTU, we would predict that the OFA system will reduce NOx to below 0.4 LBS / million BTU. CO and LOI will definitely increase. As this is a "partial" OFA system, we have no way (no operational experience) to predict performance impact to these items.

Budgetary Pricing and Progress Payment Schedule (1 unit only)

Budgetary OFA and SH Platen – Materials $ 1,200,000

Budgetary OFA and SH Platen – Installation * $ 2,300,000 - $ 2,900,000
* We are still working on this price.

Payments:

% Of Price	Milestone
50% of material	Receipt of Raw Mat'l at Shop
50% of material	Shipment Complete On-Site
50% of installation	Installation Mid-point
50% of installation	Installation Complete

Delivery and Installation

Delivery on-site for items 1 and 2 as described above is approximately 7 months after receipt of acceptable order. Installation time will require approximately 5 weeks not including mobilization or de-mobilization time.

Commercial Terms and Conditions

This proposal is predicated upon the application of B&W Standard Terms and Conditions.

Technical Conditions

This proposal is based on design and manufacturing in accordance with ASME Boiler and Pressure Vessel Code along with B&W technical design and manufacturing standards, which shall form the technical basis of a resulting contract.

We look forward to your favorable evaluation of this budgetary proposal and appreciate the opportunity to be of service to Intermountain Power. Please feel free to contact us if you require additional information.

Very truly yours,

BABCOCK & WILCOX COMPANY

Roger J. Kleisley
Regional Project Manager

cc: M. A. Costanzo – Barberton Service Projects
J. S. Metzger – Barberton Service Projects
G. S. Bernstein – Denver Sales
J. B. Doyle – Denver Sales
R. W. Wewer – Denver Service
W. A. Willman – BWCC Denver

From: "Bernstein, Gary S" <gsbernstein@babcock.com>
To: <JIM-N@ipsc.com>, <ralph-n@ipsc.com>
Date: 8/21/02 2:03PM
Subject: IPSC Boiler Modifications Summary of B&W and IPSC August 20, 2002teleconference B&W Proposal No. P-003111

James/Ralph,

Please reference attached letter that summarizes the teleconference between James Nelson and B&W yesterday. The letter also includes our response to James' questions.

Looking forward to further discussions.

Regards,

Gary S. Bernstein, P.E.
District Sales Manager
Babcock & Wilcox

<<IPSC Clarifications_GSB-008.doc>>

CC: "Tedrow, Robert L" <rltedrow@babcock.com>, "Kleisley, Roger J" <rjkleisley@babcock.com>, "Willman, William A" <wawillman@babcock.com>, "Wewer, Robert W" <rwwewer@babcock.com>

From: <fred.hess@power.alstom.com>
To: <RALPH-N@ipsc.com>
Date: 8/1/02 11:04AM
Subject: IPSC RFP #'s 45574 and 45576

Hello Ralph:
In confirmation of my telcon to you yesterday, I regret to advise that ALSTOM Power respectfully declines to submit an offering in response to your RFP # 45576 "U1-2 Boiler Uprate Modifications". The required project schedule and other commercial requirements can not be met by ALSTOM at this time.

Upon thorough review of your RFP #45574 "Forced Oxidation System" for U1-2, we also regretfully decline to submit an offering. Though ALSTOM has designed and supplied materials (and installation labor) for similar Forced Ox systems in the past, your RFP appears to require only the design engineering packages necessary for the procurement and supply of materials by others. ALSTOM's design engineering exists to support its product lines. We are not liscensed to sell our engineering alone...similar to what an AE does. Your RFP format seems more tailored to an AE than to a design engineering/manufacturer such as ALSTOM. Should you decide to rebid the project as a "design and material supply" or "turnkey" project, we would be happy to submit an offering.

Thank you very much for considering ALSTOM for both of the above projects. Though we regret not being able to respond this time, please consider us on any future similar work in your plant.

Sincerely,
Fred Hess

Sales Manager
ALSTOM Power

CC: <jim-n@ipsc.com>, <yan.lachowicz@power.alstom.com>, <charles.wright@power.alstom.com>, <pat.bartley@power.alstom.com>, <larry.metz@power.alstom.com>, <rick.tacy@power.alstom.com>

From: <david.moyeda@ps.ge.com>
To: <jim-n@ipsc.com>
Date: 7/15/02 5:30PM
Subject: Modeling Experience List

As per our call this morning, attached please find an experience list for modeling of overfire air application to utility boilers. You will find that this list closely parallels the list that Todd sent you previously. We have also completed an analysis for an OFA system that just started up last week on a 250 MW boiler.

I have also attached a presentation showing our overall modeling capabilities. There are a couple of slides on our thermal performance analysis model in this presentation. If you would like more details on our thermal analysis model, please let me know.

We look forward to working with you on this project.

Best Regards,

David Moyeda
GE EER
18 Mason
Irvine, CA 92618
(949) 859-8851
(949) 859-3194 FAX
DC 260-1077
david.moyeda@ps.ge.com

CC: <william.kuehn@ps.ge.com>, <dean.draxton@ps.ge.com>, <blair.folsom@ps.ge.com>, <todd.melick@ps.ge.com>, <don.cook@ps.ge.com>

From: <david.moyeda@ps.ge.com>
To: <jim-n@ipsc.com>
Date: 8/12/02 7:46AM
Subject: Modeling SOW Follow Up

Jim:

I just wanted to check to see if you had any questions about the modeling information that I sent you. Also, do you know when the specification for the modeling might be released?

Best Regards,

David Moyeda
GE EER
18 Mason
Irvine, CA 92618
(949) 859-8851
(949) 859-3194 FAX
DC 260-1077
david.moyeda@ps.ge.com

From: <todd.melick@ps.ge.com>
To: <jim-n@ipsc.com>
Date: 7/15/02 3:04PM
Subject: OFA Turnkey

I took the same spreadsheet and added a column to note turnkey. As we mentioned most have not been. We provide technical direction on site during the outage and the utility contracts with the construction company. This is lower cost to the utility.

<<Exper-OFAturnkey.xls>>

Todd Melick
Director, Burner Systems Engineering
GE EER
Phone 330-684-5341
Fax 330-684-2110
todd.melick@ps.ge.com

From: "Kleisley, Roger J" <rjkleisley@babcock.com>
To: <jim-n@ipsc.com>, <dean-w@ipsc.com>
Date: 8/1/02 5:25AM
Subject: Re: Intermountain Power

Dean (and James)

I wanted the opinionion of my experts to insure what I thought/told you was 100% correct. Please see their responses to 3 of my four questions below.

Our engineering people doubt that the directional spouts can be relocated without removing the cyclone seperators from the drum. There will be 16 directional spouts to remove (probably doable without removal of the seperators as long as "salvaging" is not in your plans) and 16 new (or re-used) spouts to be added (undoubtly more difficult to do). Talking about "1/2 drum length", this would occur at approximately the 1/4 & 3/4 point of the length on both sides of the drum (4 total locations).

Dean... Based on this new information, do you want the directional spout engineering & material included in the re-bid or should I just work up the drum level scope??????

Roger
----- Forwarded by Roger J Kleisley/BARB/PGG/MCD on 08/01/2002 06:47 AM -----

John R Cline
07/31/2002 06:26 PM

To: Roger J Kleisley/BARB/PGG/MCD@PGG
cc: Mel J Albrecht/BARB/PGG/MCD@PGG, Michael A Costanzo/BARB/PGG/MCD@PGG, John E Monacelli/BARB/PGG/MCD@PGG, Harshad R Patel/BARB/PGG/MCD@PGG, Robert L Tedrow/BARB/PGG/MCD@PGG, Jim J White/BARB/PGG/MCD@PGG
Subject: Re: Intermountain Power <<Roger J Kleisley>>

Roger,

My comments are in bold below.

John

Roger J Kleisley
07/30/2002 05:47 PM

To: John R Cline/BARB/PGG/MCD@PGG, Mel J

Albrecht/BARB/PGG/MCD@PGG
cc: Robert L Tedrow/BARB/PGG/MCD@PGG, Michael A Costanzo/BARB/PGG/MCD@PGG, Robert W Wewer/BARB/PGG/MCD@PGG, Gary S Bernstein/BARB/PGG/MCD@PGG
Subject: Intermountain Power

John,

Confirming our phone conversation, I need the following information.

1) If IP operates at original 6.6 million steam flow, confirm that baffling would not be required. (I don't see how it would..... unless item 3 comes into play).

Ideally, all three drum internal modifications, moving the drum level sensing lines, changing the directional spouts and adding the baffles, should be made even at the original steam flow of 6600 Klb/hr. The Intermountain Power units are two of a handful of RB units designed with 4 levels of riser penetrations to the drum. Since the time these units were designed, we have developed methods for volumetric analysis of drum flows that give us better insight into drum level balancing. A unit designed today would have risers and downcomers located differently.

2) Can/should directional spout modification be done if baffles are not (i.e. should both be done or not done concurrently)?

If construction or the customer believes they can make the directional spout modifications without removing the cyclones from the drum, there could be some advantage even without adding the baffles. If the cans have to come out to make the spout changes, we recommend making the baffle modifications at the same time.

3) Does the baffling/directional spouts have an impact on the drum level problems..... i.e. if they did the sensing relocation only what is the added benefit if any to helping their drum level problem (note that this is still at 6.6 million steam flow)?

The drum analysis was performed at 6.6 Mlb/hr (and possibly also at 6.9 Mlb/hr). The increased steaming rate would not change the result of the analysis, just the magnitude of the unbalance. The trends would be the same. The baffles and directional spout changes do have an impact on the customer's drum level unbalance. The volumetric analysis indicates concerns with riser inflow versus downcomer outflow. The baffles will direct the riser inflow to specific cyclones while the directional spouts will direct the underflow in the desired direction.

Having said this, there is some possibility that changing the sensing lines alone would be beneficial from an operations standpoint. While making the sensing line changes will not change what in happening in the drum, the gauge glass may not see the significant variations in drum level. The drum level fluctuations will still be there, the operator just will not see them.

4) In modifying the sensing connections, is there any benefit or problem with extending their range (please remember that IP modified the range of their gauge glass and moved the trip points)?

I do not remember how or how much they extended their gauge glass range. By copy to Mel, can you address this?

Roger

CC: "Costanzo, Michael A" <macostanzo@babcock.com>

From: "DaleN" <dnaughton@teiservices.com>
To: "'James Nelson'" <jim-n@ipsc.com>
Date: 9/19/02 7:49AM
Subject: TEI Construction

Mr. Nelson,

Please find attached a letter confirming our commitment to your company to work with BBPI and perform the site work on the Installation of Boiler Uprate on Units 1 and 2.

I am also faxing you a signed copy of the letter for your files.

We hope this addresses any concerns, and, if you wish to talk to me directly please call me at (864) 879-6860.

Thank you for your consideration.

Dale Naughton
President

CC: "'Roger Hessel'" <rhessel@bbpwr.com>

Telephone Conversation Record

Note to Project File:

Phone Conversation with:

Mr. Roger Kleisley
Regional Project Manager
Babcock & Wilcox
(330) 860-1129

I reviewed with Mr. Kleisley the drawings I felt needed to be issued with an upcoming bid package for modifying our boilers at IGS. I noted to him that they were primarily 'J' (arrangement) type drawings with a very small number of 'D' and 'E' type drawings. The purpose of the drawings being to describe the required scope of work.

Mr. Kleisley stated that he was agreeable to allow us to issue this package of drawings to the intended bidders in order to ensure that the same scope was being addressed by all bidders. Mr. Kleisley added that he understood the position publicly held utilities are in, having a mandate to bid all work.

Mr. Kleisley and I discussed the fact that all bidders were obliged to prepare their own fabrication drawings and that each had visited the site to obtain dimensions for that purpose. Mr. Kleisley further noted that B&W is fine with other bidders examining proprietary boiler drawings and information, in addition to the package first discussed, as long as it is done at the site and the drawings are not sent out to them.

Mr. Kleisley and I also discussed ongoing issues with boiler platen surface evaluation.

James Nelson
IPSC Engineering

MEMORANDUM

INTERMOUNTAIN POWER SERVICE CORPORATION

TO: George W. Cross

FROM: Dennis K. Killian

DATE: December 23, 2010

SUBJECT: Award of Boiler Model Contract To GE/EER

We recommend award of the boiler modeling contract to GE Energy and Environmental Research Corporation. Of the three bids solicited only two were received. Of these two, GE was the lowest cost and the only responsive bid.

The attached IPSC specification and offering package from GE covers the key aspects of both the gas side (CFD) model for prediction of combustion performance and emissions considerations, and a thermal model for prediction of steam side performance. The models will be executed at various loads including verification of existing operation and the new full load level of 950MW.

A focus of this model will be the verification of the proposed boiler modifications design by Babcock Borsig. The contract with Babcock Borsig details the requirements for Borsig to provide all required design geometric and performance data to the 'Modeling Engineer' for verification of design adequacy. Borsig is required to reconcile and/or accommodate all concerns raised by the Modeling Engineer within the Borsig design.

GE/EER has considerable experience in both design and retrofit of combustion technologies into existing steam generators. There are number of adjustments to Borsig's original design which could be implemented during fabrication or installation if so desired. At the very least the model would provide valuable input for system adjustment and operational guidance for combustion optimization. Indicate your approval by signing below.

Dennis K. Killian Superintendent - Technical Services	George W. Cross President & COO

JHN:

Environmental Performance Discussion
Conf 3 4/19/04 1:00pm

Agenda

Item

1. Review of key operating permit provisions - Env. Group

2. Review of current operating status of Unit 1- Operations
   - Operating parameters
   - Noted system malfunctions
   - Fuel source outlook

3. Review of emissions limits and published philosophy

4. Review of startup plans for Unit 2 OFA

5. Review of projected testing schedule for Unit 2
   - Support requirements

6. Interim (worst case) operating guidelines

July 15, 2002 File: b2877

Mr. Eric J. Tharp
Operating Agent for the Intermountain Power Project
Los Angeles Department of Water and Power
P.O. Box 51111, Room 1263
Los Angeles, CA 90051-0100

Dear Mr. Tharp:

Boiler Modifications Specification Approval
Budgeted Capital Project IGS02-14

Attached is the proposed bid package for boiler modifications associated with the 950 MW uprate. This work is scheduled to be completed during the upcoming Unit 1 outage and the subsequent Unit 2 outage in 2004. We request your approval as soon as possible to avoid impacting the outage schedule.

Preliminary boiler modeling work both in-house and with Babcock & Wilcox has led us to include an overfire air system as part of these modifications. Although we are confident of our ability to maintain NOx emissions at acceptable levels following the 950 MW uprate, the models are emphasizing that doing so, at times, may compromise our ability to maintain required outlet steam temperatures and pressures.

Results of the 950 MW testing recently completed have confirmed the effect of certain coal sources in causing significant NOx impacts. The model runs completed as a part of the preliminary design effort have shown that the addition of some form of overfire air system will provide both a reduction in NOx formation as well as improved superheat temperatures under all operating modes.

The associated specification for these modifications has been written in a manner that will allow us to combine the positive effects of an overfire system with superheat surface enhancement. The detailed model prepared by the successful bidder will provide the basis for designing the recommended combination of these modifications. Preliminary estimates indicate that the anticipated scope, including both an overfire air system and a platen superheater surface addition can be accomplished within the originally approved budget for this project.

Questions regarding the content of this specification may be directed to James H. Nelson at (435) 864-6464.

Sincerely,

George W. Cross
President & Chief Operations Officer

JHN/JKH:jmg

cc: Neil Clay

FUEL E

For the month of: **JANUARY 2002**

COAL ANALYSIS

	AS RECEIVED	DRY BASIS
% Moisture	6.44	xxxx
% Ash	6.24	6.67
% Volatile	33.55	35.86
% Fixed Carbon (by diff.)	53.77	57.47
% Sulfur	1.08	1.16
BTU/LB	12877	13764
% Fluorine	0.0061	0.0065
	HGI =	48.0

ASH ANALYSIS

	IPSC LAB
% Sodium Oxide, Na20, Ignited Basis =	0.83
Fusion Temp., Reducing Atmosphere; ID =	2221
ST =	2277
HT =	2328
FT =	2425

FUEL E

For the month of: **FEBRUARY 2002**

COAL ANALYSIS

	AS RECEIVED	DRY BASIS
% Moisture	5.58	xxxx
% Ash	9.65	10.22
% Volatile	33.63	35.62
% Fixed Carbon (by diff.)	51.14	54.16
% Sulfur	1.10	1.17
BTU/LB	12569	13312
% Fluorine	0.0063	0.0067
	HGI =	46.2

ASH ANALYSIS

	IPSC LAB
% Sodium Oxide, Na20, Ignited Basis =	0.74
Fusion Temp., Reducing Atmosphere; ID =	2252
ST =	2349
HT =	2520
FT =	2590

FUEL E

For the month of: **MARCH 2002**

COAL ANALYSIS

	AS RECEIVED	DRY BASIS
% Moisture	5.75	xxxx
% Ash	7.66	8.12
% Volatile	34.52	36.63
% Fixed Carbon (by diff.)	52.07	55.25
% Sulfur	1.17	1.24
BTU/LB	12941	13730
% Fluorine	0.0063	0.0067
	HGI =	44.7

ASH ANALYSIS

	IPSC LAB
% Sodium Oxide, Na20, Ignited Basis =	0.60
Fusion Temp., Reducing Atmosphere; ID =	2248
ST =	2332
HT =	2448
FT =	2543

FUEL E

For the month of: **APRIL 2002**

COAL ANALYSIS

	AS RECEIVED	DRY BASIS
% Moisture	5.52	xxxx
% Ash	7.09	7.50
% Volatile	35.01	37.06
% Fixed Carbon (by diff.)	52.38	55.44
% Sulfur	1.18	1.25
BTU/LB	12961	13718
% Fluorine	0.0064	0.0068
	HGI =	46.7

ASH ANALYSIS

	IPSC LAB
% Sodium Oxide, Na20, Ignited Basis =	0.86
Fusion Temp., Reducing Atmosphere; ID =	2237
ST =	2279
HT =	2305
FT =	2428

FUEL E

For the month of: **MAY 2002**

COAL ANALYSIS

	AS RECEIVED	DRY BASIS
% Moisture	5.18	xxxx
% Ash	7.70	8.12
% Volatile	35.00	36.91
% Fixed Carbon (by diff.)	52.12	54.97
% Sulfur	1.15	1.21
BTU/LB	13010	13722
% Fluorine	0.0046	0.0048
	HGI =	45.9

ASH ANALYSIS

	IPSC LAB
% Sodium Oxide, Na20, Ignited Basis =	0.93
Fusion Temp., Reducing Atmosphere; ID =	2161
ST =	2195
HT =	2388
FT =	2536

FUEL E

For the month of: **JUNE 2002**

COAL ANALYSIS

	AS RECEIVED	DRY BASIS
% Moisture	4.31	xxxx
% Ash	8.26	8.63
% Volatile	35.48	37.08
% Fixed Carbon (by diff.)	51.95	54.29
% Sulfur	1.10	1.15
BTU/LB	12942	13525
% Fluorine	0.0065	0.0068
	HGI =	46.8

ASH ANALYSIS

	IPSC LAB
% Sodium Oxide, Na20, Ignited Basis =	0.75
Fusion Temp., Reducing Atmosphere; ID =	2238
ST =	2356
HT =	2491
FT =	2577

From: <cjanik@bbpwr.com>
To: <jim-n@ipsc.com>
Date: 9/11/02 3:00PM
Subject: Expected Emission Data for Full Load Operation - Units 1 & 2

James Nelson,

Based upon our conversation today I am forwarding to you the expected emission data for full load operation at Intermountain Units 1 & 2.

Full Load Conditions:

Steam Flow	6,750,000 lbs/hr
Steam Throttle Pressure	2400 psig
SH Steam Temperature	1005 F
Mills in Operation	7
Fuel Flow	< 385 tons/hr
Excess Air	13.5 - 18.0%
Percent OFA	15%

Expected NOx = 0.34 lbs/mmBTU
Expected CO = 75 ppm

If you have any further questions, please feel free to call either Roger Hessel or myself.

Carl Janik
Proposal Engineer BBPI
508-854-3711

CC: <rhessel@bbpwr.com>, <ktoupin@bbpwr.com>

From: <larry.swanson@ps.ge.com>
To: <jim-n@ipsc.com>
Date: 3/5/03 3:40PM
Subject: Revised Final Report

James,

Attached is the revised main text of the final report. I'll give you a call this week to confirm you received the report.

Best Regards,

<<3681_IPSC_Final.pdf>>

> g GE Power Systems
Energy and Environmental Research Corp.

Larry W. Swanson, Ph.D.
GE EER
18 Mason
Irvine, CA 92618
(949) 859-8851 x148
(949) 859-3194 (fax)
larry.swanson@ps.ge.com

From: <larry.swanson@ps.ge.com>
To: <jim-n@ipsc.com>
Date: 3/5/03 3:41PM
Subject: Revised Final Report - Appendices

James,

Attached are the revised Appendices for final report.

Talk to you later,

<<FINAL_APPENDIX 1_2.pdf>>
> g GE Power Systems
Energy and Environmental Research Corp.

Larry W. Swanson, Ph.D.
GE EER
18 Mason
Irvine, CA 92618
(949) 859-8851 x148
(949) 859-3194 (fax)
larry.swanson@ps.ge.com

INTERMOUNTAIN POWER SERVICE CORPORATION

☒ REQUISITION FOR CAPITAL EQUIPMENT

☐ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Structural Mod Option Evaluation for Boiler Modification Project

Date: 11/25/02	
Req./PA No: 185825	
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Black & Veatch
11401 Lamar Ave
Overland Park, KS
Attn: John Morrow (913)458-2516

Account No. 1SGX-503
Work Order No. 02-60456
Project No. IGS02-14

Qty	Unit	Description Noun Adjective Catalog # Seller or Manufacturer	Unit Cost	Extension
1	ea	Services, Engineering, structural evaluation of	$3,000.00	$3,000.00
		9th floor diagonal brace interference with new		
		overfire air duct. Evaluation to include on-site		
		inspection and analysis for relocation/substitu-		
		tion of 4 existing braces.		
		TOTAL ESTIMATED COST		$3,000.00

Remarks: This is a sole source requisition due to B&V familiarity with the original boiler structural design. This work to become a release under the existing Services Agreement with Black & Veatch. Contract #03-45583

Delivery requested by [Date] 12/26/02 Originator James Nelson

Dept. Mgr/Supt. Date Station Manager Date Operating Agent Date

IP7_036842

INTERMOUNTAIN POWER SERVICE CORPORATION

X REQUISITION FOR CAPITAL EQUIPMENT

♦ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Boiler model to analyze recommendations from boiler modifications contractor prior to fabrication and installation. Boiler to include both thermal and gas side models providing both modification and operational guidance.

Date:	
Req./PA No:	181221
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Bid

Account No. 1SGX-402

Work Order No. 02-60456

Project No. IGS02-14

Qty	Unit	Description Noun Adjective Catalog # Seller or Manufacturer	Unit Cost	Extension
1	job	Services, Boiler Computer Model. Computer model	$100,000.00	$100,000.00
		to be constructed and executed in accordance with		
		the attached boiler model specification. Model		
		shall accurately reflect the modifications		
		specified by the boiler contractor and IPSC		
		within contract 02-45576.		
		Modeling work shall be completed and recommenda-		
		tions provided to IPSC within 60 days of modeling		
		contract award. Modeling recommendations shall		
		include specific direction regarding adequacy of		
		design in overfire air mixing/penetration, impact		
		of platen surface on steam temperatures and conf-		
		irmation of LOI and furnace cleanliness targets.		
		TOTAL ESTIMATED COST		$100,000.00

Remarks: This requisition needs priority attention to maximize value of the modeling results.

Delivery requested by [Date] 8/26/02 Originator James Nelson

Dept. Mgr/Supt. Date Station Manager Date Operating Agent Date

LIST OF SUGGESTED BIDDERS

Mr. Steven A. Lefton
Aptech Engineering Services, Inc
1253 Reamwood Ave.
Sunnyvale, CA 94089
(408)472-0360

Mr. Roger Kleisley
Babcock & Wilcox
90 East Tuscarawas Ave.
P.O. Box 665
Barberton, OH 44203-0665
(330)860-1129

Mr. Todd Melick
GE Energy and Environmental Research Corp.
1345 North Main Street
P.O. Box 153
Orrville, OH 44667
(330)684-5341

Drawings: The following drawings are being provided for reference purposes only. Dimensions on these drawings are not guaranteed by IPSC.

Dwg. Name
950 MW Unit Test Data (Excel File)
Boiler Buckstays
Boiler Front Wall
Boiler Loading Diagram (Sheet 1)
Boiler Loading Diagram (Sheet 2)
Boiler Plan View
Boiler Front Wall (Sheet 1)
Boiler Front Wall (Sheet 2)
Boiler Side Elevation
Boiler Structural Steel (South)
Furnace Front Wall Panel
Secondary Superheat Inlet
Secondary Superheat Platen
Burner Port (60A)

(Note to Purchasing Agent: these drawings are available in electronic format and have already been distributed as a part of an earlier review.)

PART F - DETAILED SPECIFICATIONS

DIVISION F2 - DETAILED REQUIREMENTS

1. General: The scope of this contract includes the preparation, execution, utilization, interpretation, analysis and recommendations resulting from a boiler thermal and gas side computer model of the Intermountain Generating Station (IGS) Units 1 & 2 Steam Generators. This model developed by the Modeling Engineer, shall be used for verification of design parameters established and recommended by a third party, boiler contractor to IPSC.

2. Steam Generator Model: The boiler model shall be prepared specifically for simulation of a Babcock & Wilcox carolina- type, balanced-draft, drum-type, pulverized coal fired steam generator. The combustion system consists of 48 each dual-register burners mounted in opposed-fired, compartmentalized windboxes.

   a. The Modeling Engineer shall consult with IPSC throughout the model design development process allowing IPSC to participate in the verification of empirically based modeling data, operating practices and constraints.

   b. All bidders shall provide estimates of manhours required from IPSC in location, preparation, and verification of boiler model data and operating constraints. Any on-site facilities or support must also be clearly identified.

   c. The boiler model shall include simulation of the IGS boilers at rated conditions, under the following operating modes:
      1. Boiler output flow of 6.2MMlbs/hr. (Verification of existing operation)
      2. Boiler output flow of 6.64MMlbs/hr. (New full load point of 950MWg)
      3. Boiler output flow of 6.9MMlbs/hr. (Valves Wide Open Design)
      4. Boiler ouput flow of 5.0MMlbs/hr. (Approximate 3/4 load point)
      5. Boiler output flow of 3.32MMlbs/hr. (Approximate half load point)

   d. The boiler model shall take fully into consideration the variations in fuel chemistry and percentage of total fuel consumption from each fuel source. The following fuel source supply percentages represent the most recent 6 months (Jan - June, 2002) from the 6 current IGS fuel suppliers: (See fuel analyses attached)

Source	Ave.	Range
Fuel A -	8.0%	6.0 - 10.0%
Fuel B -	32.0%	28.0 - 37.0%
Fuel C -	13.0%	12.0 - 16.0%
Fuel D -	38.0%	33.0 - 42.0%
Fuel E -	9.0%	7.0 - 10.5%

   e. The boiler base model shall be prepared to simulate the configuration and operation of the existing, unmodified boiler. A full set of boiler model inputs and results shall be reviewed and approved by IPSC prior to proceeding with the modified model runs.

f. Following successful operation of the boiler base model , the base model shall thereafter be modified in accordance with the recommendations provided by IPSC from a third party boiler contractor. The Modeling Engineer shall ensure that the model reflects the boiler contractors proposed changes in every material respect, including operational data, assumptions and boundary conditions.

g. Within the design of the model, the Modeling Engineer shall review all operational impacts on associated equipment and systems such as fans, burners and dampers. Any concerns regarding operating limitations or increase power demands noted within the modeling/design phase shall immediately be brought to the attention of the Contract Administrator.

h. Among the operational parameters to be evaluated shall be:
- Superheat Temperature & Pressure
- Reheat Temperature
- Furnace Exit Gas Temperature
- Economizer Exit Gas Temperature
- Generation of Oxides of Nitrogen
- Furnace Heat Absorption and Cleanliness
- Superheat & Reheat Attemperator Sprays
- Carbon Monoxide Generation
- Burner Metal Temperatures both In-service & Out-of -service
- Boiler Metal Temperatures throughout the gas path

3. Model Results Reconciliation: Model inputs and results shall be used to provide design and installation guidance to IPSC and the boiler contractor completing modifications to the IGS steam generators.

a. All project and modeling data shall be transmitted openly and directly between the Modeling Engineer, IPSC and the boiler contractor, as required for maintaining clarity and timeliness of the project.

b. The Modeling Engineer shall also provide clarification and interpretation expertise in defining all implications of his model and in issuing recommendations affecting design of the boiler modifications proposed by the boiler contractor.

4. Anticipated Boiler Modifications: The anticipated scope of changes to the IGS Steam Generators consists of the following:

a. Platen Superheat Extension:

IPSC anticipates the possibility of adding additional platen superheat surface on both Units 1 & 2, to maximize both reheat and superheat temperature support while maintaining boiler efficiency. A base design case of an additional 8 foot extension of the platen superheater element loops is the focus of this discussion.

b. Steam Generator Sootblowing System Recommendations:
The Modeling Engineer shall identify the extent to which the model is capable of providing guidance regarding expected on-line, gas path, cleaning requirements and impacts, (i.e. sootblowing system requirements and recommendations). This shall include a specific assessment of the adequacy of the present sootblowing system and provide recommendations for sootblowing system enhancements where advisable, especially in the area of the new platen surface. This analysis shall include cleanliness factor analysis and comparisons with existing operating cleanliness

c. NOx Reduction System:
IPSC also anticipates the retrofit of some type of NOx reduction technology in and around the furnace. Regardless of the type or configuration of this NOx reduction hardware, the Modeling Engineer shall simulate the system chosen by IPSC in accordance with industry standards and the design data provided by IPSC from the boiler contractor.

Based on the NOx reduction technology recommended by the boiler contractor, the Modeling Engineer shall develop a model utilizing the boiler contractor recommended operating parameters for achieving a maximum of .40MMlbs/hr for all specified fuel combinations and loads. Where the guaranteed and/or required operating parameters are not achieved using the boiler contractor recommended operating parameters, the Modeling Engineer shall modify the model to identify the changes required to meet guarantee/IPSC desired conditions.

In the case where a technology other than overfire air ports is recommended by the boiler contractor, the Modeling Engineer shall develop one additional boiler model implementing a maximum of 16 overfire air ports (8 front wall/8rear wall) for comparison of all operating and emissions parameters.

5. Review of Boiler Contractor Design:

a. To the extent allowed by the boiler contractor, the Modeling Engineer shall participate in a detailed review of the proposed and/or final design recommendations from the boiler contractor. Within this review, the Modeling Engineer shall provide advisory input regarding optimal configuration, sizing, fabrication, installation, operation and failure mode analysis of the various aspects of the boiler contractor's design.

b. The Modeling Engineer should anticipate at least one trip for two individuals to the offices of the boiler contractor. Although not yet awarded, the boiler contractor will be an entity whose head offices are located within the contiguous 48 states.

6. Technical Support:

a. Bidders shall include, within the bid offerings, the names and direct dial phone numbers of the lead modeling engineers in each area of expertise. The assigned coordinator direct dial phone number and email shall also be provided.

b. All technical personnel assigned to participate as section lead engineers within the model building process or to provide direct support/interface to IPSC shall have a minimum of 10 years experience in the issues being addressed.

7. Required Reporting: The Modeling Engineer shall provide, as a minimum, the following reports/data within the time periods specified:

a. The Modeling Engineer shall maintain a minimum of weekly contact with the IPSC Contract Administrator advising of progress made and results achieved.

b. A complete set of model inputs and results of the various model runs shall be documented and provided to IPSC within 7 days of completing each model run.

c. The Modeling Engineer shall produce a Final Report detailing the results of all model runs, model assumptions, boundary conditions, operational constraints and model results within 30 days of completion of all runs.

d. All reports shall be provided in electronic format followed up by hard copy. All text shall be in .pdf format. Large bodies of data shall be in Microsoft Excel format. Vector drawings shall be in AutoCAD format (.dwg) and raster drawings shall be in .tif (Strip G4 LSB) compatible format.

8. Schedule: The Modeling Engineer shall monitor the progress of all phases of the model construction and execution process to ensure that the contract milestones are achieved.

a. Bidders shall provide a detailed schedule showing start and completion of each phase of the steam generator model. Each activity shall be identified in a sequential manner noting the duration of each activity. Activities with large unknown variables should be noted with asterisks showing the list of variables affecting the duration.

b. Bidders shall provide a list, by name and experience level, of all boiler modeling engineers employed. The bidder shall clearly note all engineers that could step in and advance the job toward successful completion in the event that the assigned lead engineer becomes unavailable.

c. Completion of the model as early as possible is essential to the overall success of the boiler modification contract. Preferential evaluation will be afforded the shortest guaranteed schedule for completion of all model runs and recommendations regarding the proposed modifications from the boiler contractor.

9. Site Security and Access: It is the Modeling Engineer's responsibility to protect themselves and their equipment and tools from theft and vandalism as they deem necessary. IPSC will not be responsible for any theft or damage incurred by the Modeling Engineer.

   a. Only vehicles owned and insured by the Modeling Engineer shall be allowed inside the plant fence perimeter.

   b. All Modeling Engineer's employees will be given security badges by the owner and those badges shall be displayed each day to gain admittance to the plant site. All security badges shall be returned to the security contractor when the employee terminates their work at this site. Modeling Engineer's vehicles will also receive parking stickers from the security contractor allowing entrance to the plant site. Temporary badges and parking stickers are available for intermittent access.

10. Requested Performance Guarantees: For information only, the following aspects are the minimum requirements specified as performance guarantees within the specification developed for soliciting bids from several the boiler contractors. Actual performance guarantee criteria from the boiler contractor will be distributed to the Modeling Engineer as it becomes available.

    Of particular interest to IPSC are the performance parameters associated with operation at 950 Megawatts gross generation (6.75 MMlbs/hr steam flow). These include:

   a. Total NOx output of 0.40 lbs/MMBTU or less and an overall reduction of 15%. Current maximum average of 0.45 lbs/MMBTU.

   b. Superheat and reheat temperatures as well as NOx emissions must remain within the contract stated acceptable ranges throughout the test.

   c. Impact on average unburned carbon (LOIs) and carbon monoxide (CO) concentrations within the boiler.

   d. The above operational guarantees shall be verified in a steady state operational test within 30 days of installation. Steady state operation shall be defined as stable and reliable operation at and within the following operating conditions and ranges for a period of at least 7 days:

      -7 pulverizers in service (E and G Pulverizers alternately out-of-service).

-Excess air to be controlled between 2.5 to 3.2%.
-Superheat and convection surfaces maintained at 80-85% cleanliness
-Boiler tube maximum allowable metal temperatures must not be exceeded.
-Turbine throttle pressure of 2375 psi.
-Furnace cleanliness maintained at 85-90% actual cleanliness.
-Superheat attemperator spray flow at or above 50,000lbs/hr
-Reheat attemperator spray flow at 0 lbs/hr

Spec. XXXXX

LIST OF SUGGESTED BIDDERS

Mr. Fred Hess
Alstom Power Inc.
453 E. Wonderview Ave. #304
Estes Park, CO 80517
Tel: (970)586-9660

Mr. Roger Kleisley
Babcock & Wilcox
90 East Tuscarawas Ave.
P.O. Box 665
Barberton, OH 44203-0665
(330)860-1129

Mr. Kevin Davis
Babcock Borsig
5 Neponset Street
Worcester, MA 01606
(508)854-3818

TABLE OF CONTENTS

SPECIFICATIONS

PART A - DIVISION A1

NOTICE INVITING PROPOSALS

The Intermountain Power Service Corporation (IPSC) invites sealed bids for design, **supply and installation of boiler uprate modifications on Units 1 & 2** in accordance with **Specifications** ______, available in the Purchasing Section, Intermountain Power Service Corporation, 850 West Brush Wellman Road, Delta, UT 84624-9546.

Proposals shall be submitted on IPSC's bidding forms. All Proposals shall be filed with the Buyer at the above address on or before ______________.

Each Proposal shall be accompanied by a certified or cashier's check or a surety bond in the amount of ten (10) percent of the aggregate sum of the Proposal as a guarantee that the bidder shall execute the proposed Contract if awarded.

Proposals shall be subject to acceptance within, and irrevocable for, a period of ninety (90) calendar days after date of bid opening.

The right is reserved to reject any and all Proposals.

The successful bidder shall furnish a Performance Bond equal to ten (10) percent of the estimated Contract amount.

In the performance of any Contract awarded, the bidder shall not discriminate in employment practices against any employee or applicant for employment because of race, religion, national origin, ancestry, sex, age, or physical disability.

Dated: ______________________________ ____________________________________
Buyer

PART B - DIVISION B1

INSTRUCTIONS TO BIDDERS

1. Form, Signature, and Delivery of the Proposals: The bidder's Proposal shall be made on the yellow copy of the Bidding Documents. The specifications printed on white paper shall be retained by the bidder.

   The bidder's name, address, and the date shall be stated in the Proposal. The Proposal shall be signed by the person authorized to bind the bidder.

   The Proposal shall be enclosed in a sealed envelope, plainly marked in the upper left-hand corner with the name and address of the bidder. The envelope shall bear the words "Proposal for," followed by the specifications number, the title of the specifications, and the date and hour of bid opening.

   If the Proposal is mailed, it shall be addressed as follows:

   Purchasing Section
   Intermountain Power Service Corporation
   850 West Brush Wellman Road
   Delta, UT 84624-9546

   If the Proposal is sent by messenger, it shall be delivered to the Administration Building, Intermountain Power Service Corporation, 850 West Brush Wellman Road, Delta, UT.

2. Interpretations and Addenda: Should a bidder find discrepancies or omissions in the plans, specifications, or other documents, or should there be doubt as to their true meaning, the bidder shall submit to the Buyer a written request for an interpretation or clarification thereof. A request for addenda, interpretation, or clarification shall be delivered to the Buyer marked "Request for Interpretation" and will be received by the Buyer in time to permit a reasonable response before date of bid opening. Any interpretation of, or change in the documents will be made only by addendum issued to each person to whom specifications have been issued and will become a part of any contract awarded. IPSC will not be responsible for any other explanations or interpretations.

3. Correspondence: All inquiries or correspondence to IPSC prior to award of the Contract shall be addressed to the Buyer.

4. Changes or Alternatives: The bidder shall not change any wording in the documents. Any explanations or alternatives offered shall be submitted in a letter attached to the front of the Bidding Documents. Alternatives which do not substantially comply with IPSC's specifications cannot be considered. Language of negation or limitation of any rights, remedies, or warranties provided by law will not be considered part of the Proposal. Bids offered subject to conditions or limitations may be rejected.

5. Specified Materials or Equivalent: Whenever any particular material or process is specified by a patent or proprietary name, by a trade or brand name, or by the name of a manufacturer, such wording is used for the purpose of describing the material or process, fixing the standard of quality required, and shall be deemed to be followed by

the words "or equivalent." The bidder may offer any material or process which shall be the equivalent of that so specified.

6. Language: Everything submitted by the bidder shall be written in the English language.

7. Sales or Use Taxes: Prices quoted by the bidder shall not include any applicable sales or use taxes or Federal Excise Taxes.

8. Duties: Prices quoted by the bidder shall include all applicable duties.

9. Award of Contract: Any award of Contract will be made to the lowest and best, regular responsible bidder. The determination as to which is the lowest and best, regular responsible bidder may be made on the basis of the lowest ultimate cost of the materials or equipment in place and use. The right is reserved to reject any or all Proposals.

   Within thirty (30) calendar days after the date of award of Contract, the successful bidder shall sign the Contract supplied by IPSC. The Contract will be effective upon execution by IPSC.

10. Comparison of Bids: Bid comparison will be based on the lowest ultimate cost and the Contractor's experience in similar jobs.

11. Bidder's Bond: The Proposal shall be accompanied by a certified check or a cashier's check issued by a responsible bank, payable in the state of Utah to the order of Intermountain Power Agency, in an amount not less than ten (10) percent of the aggregate sum of the Proposal. A surety bond in a like amount will be accepted in lieu of a check.

    The surety bond shall be submitted on IPSC's Bidder's Bond form. The check or bidder's bond shall be enclosed in the same envelope with the Proposal.

12. Performance Bond: Within thirty (30) calendar days after date of award of Contract, the successful bidder shall furnish a Performance Bond equal to ten (10) percent of the estimated amount of the Contract.

13. Calculation of the Bonds: The estimated amount of the Proposal for the Bidder's Bond or of the Contract for the Performance Bond will be considered to be the price, including freight charges, quoted by the bidder in the Proposal Schedule, times the assumed quantity under the Comparison of Bids in Article 10 of this Division.

14. Bid Evaluation Credit: A bid evaluation credit of $100,000 per day shall be applied to each applicable bid for each full day less than the longest installation schedule bid in the respective, proposed Installation Plan. Bid evaluation credit shall not apply to the longest schedule bid. This is a bid evaluation credit only and shall not modify or supersede any part of the submitted bid package.

PART C - DIVISION C1

BIDDING DOCUMENTS

BIDDER'S BOND

(Not necessary when check accompanies bid. See below*.)

SURETY BOND

We, the undersigned principal and surety, acknowledge ourselves jointly and severally bound to Intermountain Power Agency (IPA) and Intermountain Power Service Corporation (IPSC) of the state of Utah, and the city of Los Angeles Department of Water and Power, in the sum of ____ Dollars ($__________), to be paid to IPA if the attached Proposal shall be accepted and the proposed Contract awarded to said bidder, and said bidder shall fail to execute the Contract and bond for the faithful performance thereof; otherwise this obligation to be void.

Dated: ____________________________________, 20 ________

Firm Name: ____

____

By: ____
(Signature)**

(Surety): ____

By: ____
(Signature)

*Where bidder is submitting a check in lieu of a bond, the check must be made payable to IPA and must be either certified by a responsible bank or be a cashier's check issued by a responsible bank and payable in the state of Utah.

If check is submitted herewith, state number __________________ and amount $____________.

**See Signatures, Division B1

NOTE: All signatures above must be written in ink.

PROPOSAL

The undersigned hereby proposes to furnish and deliver manpower and material to the Intermountain Power Service Corporation in accordance with **Specifications** ______

The undersigned agrees, upon the acceptance of this Proposal, to enter into and execute a Contract consisting of the documents identified in Part D of said Specifications for furnishing and delivering the items embraced in the accepted Proposal at the prices named in the accompanying Proposal Schedule and to execute a bond conditioned upon the faithful performance of the Contract.

The undersigned furthermore agrees that, in case of failure to execute such Contract and provide the necessary Performance Bond, the check or Bidder's Bond accompanying this Proposal and the monies payable thereon shall be forfeited to and remain the property of the Intermountain Power Agency.

The undersigned declares under penalty of perjury that such Proposal is genuine, and not sham or collusive, nor made in the interest or in behalf of any person or entity not herein named, and that the bidder has not directly or indirectly induced or solicited any other bidder to put in a sham bid, or any other person, firm, or corporation to refrain from bidding, and that the bidder has not in any manner sought by collusion to secure for itself an advantage over any other bidder.

I declare under penalty of perjury under the laws of the state of Utah that the foregoing is true and correct.

Date: ______________________________, 20 ________

Bidder: ______________________________________

Address: _____________________________________

____

Signed By: ____________________________________
(Authorized Signature)

Print Name: ___________________________________

Title: ____

Spec. XXXXX

Contract No. _______

Bond No. _________

LABOR, MATERIAL, AND PERFORMANCE BOND

1. Know all persons by these presents, that

____

(Insert Contractor's name and address or legal title.)

____

as Principal, hereinafter called Contractor, and

____

as Surety, hereinafter called Surety, are held and firmly bound unto Intermountain Power Agency, Intermountain Power Service Corporation, hereinafter called IPSC, and the city of Los Angeles Department of Water and Power, as Obligee, in the amount of ____________________________ Dollars ($_________) for the payment whereof Contractor and Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

2. WHEREAS, Contractor has by written agreement dated

______________________, 20________, entered into a Contract with IPSC for

____

____

in accordance with Contract No. _________ which Contract is attached hereto and by reference made a part hereof, and is hereinafter referred to as the Contract.

NOW, THEREFORE,

3. THE CONDITION OF THIS OBLIGATION is such that, if Contractor shall promptly and faithfully perform said Contract, and shall promptly make payment to all claimants for labor and material used or supplied for use in the performance of the Contract, then this obligation shall be null and void; otherwise, it shall remain in full force and effect.

4. Whenever Contractor shall be, and declared by IPSC to be, in default under the Contract, IPSC having performed IPSC's obligations thereunder, the Surety may promptly remedy the default, or shall promptly:

   a. Complete the Contract in accordance with its terms and conditions, or

   b. Obtain a bid or bids for submission to IPSC for completing the Contract in accordance with its terms and conditions, and upon determination by IPSC and Surety of the lowest responsible bidder acceptable to IPSC, arrange for a

Contract between such bidder and IPSC, and make available as work progresses (even though there should be a default or a succession of defaults under the Contract or Contracts of Completion arranged under this paragraph) sufficient funds to pay the cost of completion less the balance of the Contract price, but not exceeding the amount of the bond. The term "Balance of the Contract price," as used in this paragraph, shall mean the total amount payable by IPSC to Contractor under the Contract and any amendments thereto, less the amount previously paid by IPSC to Contractor.

5. Upon failure of Contractor to timely pay laborers and material men, Surety agrees to discharge such obligation in an amount not exceeding the sum set forth above and also, in case suit is brought upon this bond, a reasonable attorney's fee to be fixed by the court. This bond shall inure to the benefit of any and all persons named in Title 14, Chapter 2, Utah Code, as amended, so as to give a right of action to such persons or their assigns in any suit brought upon this bond.

6. No right of action shall accrue on this bond to or for the use of any person or corporation other than named herein, or the heirs, executors, administrators, or successors and assigns of IPSC, except as provided by statutory or regulatory provisions relating to Contractor's bonds upon public and private contracts, the provisions of which are made a part thereof as a supplemental description of the Surety's obligations herein.

7. The Surety hereby waives notice of any change orders or extensions of time made by IPSC in accordance with the terms of the Contract.

8. SIGNED AND SEALED this ____________ day of _________________ A.D. 20_____

In the presence of: ____

(Principal)

(Seal)

___________________________________ ___________________________________

(Witness) (Title)

(Seal)

____

(Surety)

___________________________________ ___________________________________

(Witness) (Title)

PART C - DIVISION C2

BIDDING DOCUMENTS - PROPOSAL SCHEDULE

Proposal is hereby made to furnish and deliver to IPSC manpower and material as required for **design, supply and installation of boiler uprate modifications on Units 1&2,** F.O.B. Intermountain Power Service Corporation, 850 West Brush Wellman Road, Delta, UT, in accordance with **Specifications XXXXX**,and the following:

Bid Submittals: Each bidders shall include the following information with their bid:

a. Approximate Engineering, Material Manufacturing & Delivery Schedule

b. Proposed Installation Plan (See Section 4.0)

c. Proposed Subcontractor List (including contacts, references and phone #s.) All subcontractors shall be approved by the Contract Administrator prior to mobilization.

d. Bidders shall submit a required access plan showing location and extent of all required scaffolding in the event the Owner elects to provide all required scaffolding.

Prices: Bidders shall complete and submit the following pricing schedule. Prices are to be stand-alone, line item pricing unless specified otherwise by the bidder or indicated otherwise within the following line items.

ITEM	BID Unit 1	BID Unit 2
Preparation and implementation of a boiler model designed to accurately represent Intermountain Units 1 & 2. Boiler model to provide the technical basis for optimization of boiler performance as identified with the attached specifications...	________	________
Design, procure, fabricate and deliver an 8 ft. platen pendant tube extension set, including alignment appurtenances for Unit 1 beginning 3/1/2003 and Unit 2 beginning 2/28/2004. (Unit 2 procurement release contingent upon successful installation of Unit 1)...	________	________
Installation of 8ft. platen pendant tube extension sets on Units 1 & 2. (Installation of Unit 1 will be awarded to the material supply bidder. Award of Unit 2 extensions will be based on Unit 1 experience)..........	________	________
Design, procure, fabricate, deliver and install an overfire air system on Units 1& 2 to achieve NOx output reduction of 15% reduction and a maximum NOx operating output of 0.40lbs/MMBTU. (Award of the Unit 2 OFA system will be based on Unit 1 experience)	________	________

Design, procure, fabricate, deliver and install a complete overfire air system for maximum allowable NOx reduction with the existing combustion system hardware presently in use at Intermountain.......... _________ _________

Installation of 250 Owner-supplied, split-ring castings on the Intermediate Superheat Pendants.. _________

____

Design, procure, deliver, install and remove a complete scaffold structure for all applicable boiler internal work on Units 1 & 2. (Boiler internal scaffold is detailed within the attached specification)... _________ _________

Provide technical service support as needed throughout the project, including a minimum of 2 wks. on-site technical support during startup and tuning and one additional week for technical support during operational testing of the boiler following the outage........................... _________ _________

Cash Terms: A discount for prompt payment is offered of ____________ percent for Contract payments made within ___________ calendar days after date of acceptance or delivery and receipt of invoice.

Taxes: The foregoing quoted prices are exclusive of all applicable sales and use taxes.

Form of Business Organization: The bidder shall state below the form of its business organization.

Bidder is: ____________________________ (Corporation, Partnership, Limited Partnership, Individual)

If a partnership, the bidder shall state below the names of the partners. If a corporation, the bidder shall state below the names of the president and of the secretary.

____________________________ ____________________________

____________________________ ____________________________

Person to Contact: Should IPSC desire information concerning this Proposal, please contact:

Name: ____________________________ Telephone No: ______________________

Address: ____

PART D - DIVISION D1

CONTRACT DOCUMENTS

The documents listed in the Table of Contents, the reference specifications, any documents listed below, and the bidding documents as expressly agreed to by IPSC shall constitute the Contract. Said documents are complementary and require complete and finished work. Anything shown or required of the Contractor in any one or more of said documents shall be as binding as if contained in all of said documents. The Contractor shall not be allowed to take advantage of any error, discrepancy, omission, or ambiguity in any document, but shall immediately report to the Chief Operations Officer, in writing, any such matter discovered. The Chief Operations Officer will then decide or correct the same and the decision will be final.

Drawings: The following drawings are being provided for reference purposes only. Dimensions on these drawings are not guaranteed by IPSC.

Dwg. Name
950 MW Unit Test Data (Excel File)
Boiler Buckstays
Boiler Front Wall
Boiler Loading Diagram (Sheet 1)
Boiler Loading Diagram (Sheet 2)
Boiler Plan View
Boiler Front Wall (Sheet 1)
Boiler Front Wall (Sheet 2)
Boiler Side Elevation
Boiler Structural Steel (South)
Furnace Front Wall Panel
Secondary Superheat Inlet
Secondary Superheat Platen
Burner Port (60A)
Corner Insulation (40N)
Corner Port Insulation (44G)
Insulation Key
Insulation Specification
Waterwall Insulation (45H)
Windbox Insulation (ITP4.0)
Windbox Insulation (MTP4.0)

Drawings prepared by the Contractor for this project shall be submitted to the Owner for review prior to commencement of fabrication. This review shall not relieve the successful bidder of sole responsibility for the adequacy and correctness of the associated work. All project drawings shall be stamped by a registered professional engineer, licensed within the state of Utah

PART E - DIVISION E1

GENERAL CONDITIONS

1. Definitions: The following words shall have the following meanings:

   a. Bidder: The person, firm, or corporation adopting and submitting a Proposal under these specifications.

   b. Buyer: The Purchasing Agent for IPSC.

   c. Chief Operations Officer: The President and Chief Operations Officer of IPSC or designated representatives acting within the limits of their authority.

   d. Contract Administrator: The IPSC employee designated by the Chief Operations Officer with primary responsibility for administration of the Contract or designated representatives acting within the limits of their authority.

   e. Contractor: The person, firm, or corporation to whom the Contract is awarded.

   f. Directed, Required, Approved, etc.: The words *directed, required, approved, permitted, ordered, designated, prescribed, instructed, acceptable, accepted, satisfactory*, or similar words shall refer to actions, expressions, and prerogatives of the Contract Administrator unless otherwise expressly stated.

   g. Gallon: Liquid volume of 231 cubic inches at 60 degrees Fahrenheit.

   h. IPA: Intermountain Power Agency, the owner of IPP, and a political subdivision of the state of Utah, organized and existing under the Interlocal Co-operation Act, Title 11, Chapter 13, Utah Code Annotated 1953, as amended.

   i. IPP: Intermountain Power Project, consisting of Intermountain Generating Station, Intermountain Railcar, Intermountain Converter Station, Adelanto Converter Station, Intermountain AC Switchyard and associated transmission lines, microwave stations, and support facilities.

   j. IPSC: Intermountain Power Service Corporation, a nonprofit corporation, furnishing personnel to support the Operating Agent in the performance of operation and maintenance.

   k. Operating Agent: The city of Los Angeles Department of Water and Power (LADWP) which is responsible for operation and maintenance for IPP.

   l. Reference Specifications: Those bulletins, standards, rules, methods of analysis or tests, codes, and specifications of other agencies, engineering societies, or industrial associations referred to in these specifications. These refer to the latest edition, including amendments published and in effect at the date of advertising these specifications, unless specifically referred to by edition, volume, or date.

m. Subcontractor: A person, firm, or corporation, other than the Contractor and employees thereof, who supplies labor or materials on a portion of the work.

n. Ton: The short ton of 2000 pounds.

2. Materials and Work: All materials and work shall comply with these specifications. All materials and equipment furnished shall be new and unused, but this requirement shall not preclude the use of recycled materials in the manufacturing processes. All work shall be done by qualified workers in a thorough and workmanlike manner. Materials or workmanship not definitely specified, but incidental to and necessary for the work, shall conform to the best commercial practice for the type of work in question.

3. Nondiscrimination: The applicable provisions of Executive Order No. 11246 of September 24, 1965, and Bureau of Land Management regulations pertaining to nondiscrimination in employment in the performance of contracts, are incorporated herein by reference, and made a part hereof as if they were fully set forth herein. During the performance of this Contract, the Contractor shall not discriminate in its employment practices against any employee or applicant for employment because of the employee's or applicant's race, religion, national origin, ancestry, sex, age, or physical disability. All subcontracts awarded under any such contract shall contain a like nondiscrimination provision.

4. Governing Law: This Contract shall be governed by the substantive laws of the state of Utah, regardless of whether rules on the conflict of laws would cause a court to look to the laws of any other state or laws of any other jurisdiction. Any action, in law or in equity, concerning any alleged breach of or interpretation of this Contract, or concerning any tort in relation to this Contract or incidental to performance under this Contract, shall be filed only in the state or federal courts located in the state of Utah.

5. Patents and Intellectual Property: *The Contractor shall fully indemnify IPSC, IPA, and* the Operating Agent against any and all liability, whatsoever, by reason of any alleged infringement of any intellectual property rights (including, but not limited, to patents, copyrights, trademarks, or trade secrets) on any article, process, method, or application used in any designs, plans, or specifications provided under this Agreement or by reason of use by IPSC of any article or material specified by the Contractor.

6. Contractor's Address and Legal Service: The address given in the Proposal shall be considered the legal address of the Contractor and shall be changed only by written notice to IPSC. The Contractor shall supply an address to which certified mail can be delivered. The delivery of any communication to the Contractor personally, or to such address, or the depositing in the United States Mail, registered or certified with postage prepaid, addressed to the Contractor at such address, shall constitute a legal service thereof.

7. Assignment of Contract Prohibited: The Contractor shall not assign or otherwise attempt to dispose of this Contract, or of any of the monies due or to become due thereunder, unless authorized by the prior written consent of the Chief Operations Officer. No right can be asserted against IPSC, IPA, or the Operating Agent, in law or equity, by reason of any assignment or disposition unless so authorized.

If the Contractor, without such prior written consent, purports to assign or dispose of the Contract or of any interest therein, IPSC, at its option, may terminate the Contract, and IPSC, IPA, and the Operating Agent will be relieved and discharged from any and all liability and obligations to the Contractor, and to any assignee or transferee thereof.

8. Quality Assurance: The Contract Administrator has the right, but not the obligation, to subject any or all materials or equipment furnished and delivered under the Contract to rigorous inspection. Before offering any material or equipment for inspection or testing, the Contractor shall eliminate all items which are defective or do not meet the requirements of the specifications. If any items or articles are found not to meet the requirements of the specifications, the lot, or any faulty portion thereof, may be rejected. The fact that the materials or equipment have, or have not, been inspected, tested, or accepted by the Contract Administrator shall not relieve the Contractor of responsibility in case of later discovery of flaws or defects.

   Any materials testing at the jobsite that is required to determine suitability of materials within this contract, over and above visual inspection of materials and documentation , shall be charged against the contractor.

9. Extra Work or Changes by IPSC: IPSC reserves the right at any time before final acceptance of the entire work to order the Contractor to perform extra work, furnish extra material or equipment, or to make changes altering, adding to, or deducting from the work, without invalidating the Contract. Changes shall not be binding upon either IPSC or the Contractor unless made in writing in accordance with this Article.

   Changes will originate with the Chief Operations Officer who will transmit to the Contractor a written request for a Proposal covering the requested change, setting forth the work in detail, and including any required supplemental plans or specifications. Upon receipt of such request, the Contractor shall promptly submit in writing to the Chief Operations Officer a Proposal offering to perform such change, a request for any required extension of time caused by such change, and an itemized statement of the cost or credit for the proposed change. Failure of the Contractor to include a request for extension of time in the Proposal shall constitute conclusive evidence that such extra work or revisions will entail no delay and that no extension of time will be required.

   If the Contractor's Proposal is accepted by IPSC, a written change order will be issued by the Chief Operations Officer stating that the extra work or change is authorized and granting any required adjustments of Contract price and of time of completion.

   The performance of extra work or changes pursuant to the change order shall be in accordance with the terms and conditions of these specifications. No extra work shall be performed or change made unless pursuant to such written change order, and no claim for an addition to the Contract price shall be valid unless so ordered.

10. Changes at Request of Contractor: Changes may be made to facilitate the work of the Contractor. Such changes may only be made without additional cost to IPSC and without extension of time. Permission for such changes shall be requested in writing by the Contractor to the Chief Operations Officer.

11. Time is of the Essence and Extensions of Time: Time is of the essence of the Contract. Delivery shall be completed within the times and by the dates specified. Time for delivery shall not be extended except as provided in this Article.

    If the Contractor makes a timely written request in accordance with this Article, the time for delivery will be extended by a period of time equivalent to any delay of the whole work which is: (1) authorized in writing by the Chief Operations Officer, (2) caused solely by IPSC, or (3) due to unforeseeable causes (such as war, strikes, or natural disasters) and which delay is beyond the control and without the fault or negligence of the Contractor and subcontractors.

    The Contractor shall promptly notify the Chief Operations Officer in writing at both the beginning and ending of any delay, of its cause, its effect on the whole work, and the extension of time claimed. Failure of the Contractor to provide such written notices and to show such facts shall constitute conclusive evidence that no excusable delay has occurred and that no extension of time is required.

    The Chief Operations Officer will ascertain the facts and the extent of the delay and will extend the time for delivery when the findings of fact justify such an extension. The Chief Operations Officer's determination will be final and conclusive.

    IPSC will be responsible for extensions of time as herein provided, but will not otherwise be responsible in any manner or to any extent for damage directly or indirectly suffered by the Contractor by any delay.

12. Protests and Claims: If the Contractor considers any demand of the Chief Operations Officer to be outside of the requirements of the Contract, or considers any amount of payment, or any record, ruling, or other act or omission by the Chief Operations Officer to be unreasonable, the Contractor shall promptly deliver to the Chief Operations Officer a written statement of the protest and of the amount of compensation claimed.

    Upon written request by the Chief Operations Officer, the Contractor shall provide access to all records containing any evidence relating to the claim or protest.

    Upon review of the protest, claim, and evidence, the Chief Operations Officer will promptly advise the Contractor in writing of the final decision which will be binding on all parties.

    The requirements of this Article shall be in addition to, and shall not be construed as waiving, claims provisions of the Government Code of the state of Utah. The Contractor is deemed to have waived and does waive all claims for extensions of time and for compensation in addition to the Contract price except for protests and claims made and determined in accordance with this Article.

13. Limitation of Liability: It is understood and agreed that IPA shall be the party solely liable to the Contractor for payments under this Contract and for any breaches, defaults, or for any torts in the performance of or in relation to this Contract by IPA or the Operating Agent or IPSC or any officers, agents, or employees thereof, and the Contractor hereby expressly covenants and agrees that no suit shall be brought by the

Contractor against the Operating Agent or IPSC or their officers, agents, or employees or any of the purchasers of power from IPA, but that all rights or remedies that the Contractor may have or that may arise shall be asserted by the Contractor solely against IPA.

14. Independent Contractor: The Contractor shall perform said services as an independent contractor in the pursuit of its independent calling, is not an employee, agent, joint venturer, partner, or other representative of IPA, IPSC or the Operating Agent and shall be under the control of IPSC only to provide the services requested and not as to the means or manner by which the work is to be accomplished. The Contractor has no authority to act for, bind, or legally commit IPA, IPSC, or the Operating Agent in any way.

15. Drug Policy: The Contractor shall submit a current copy of its drug policy for review. IPP facilities are a drug free and zero tolerance workplace. The Contractor and its subcontractors' employees who are to perform work at the IPP site shall participate in a drug testing program prior to arrival, and at any additional time(s) during the Contract as IPSC may request.

16. Nonexclusive: This is a nonexclusive Contract. IPSC reserves the right to obtain services from other Contractors.

PART E - DIVISION E2

ADDITIONAL GENERAL CONDITIONS

1. Guarantee: The Contractor shall guarantee for a minimum period of two (2) years after installation that all materials and workmanship furnished within the scope of the contract shall be free from defects. The Contractor shall repair or replace, F.O.B. contract delivery point, all such defective materials and workmanship.

2. Payment: Payment will be made within thirty (30) calendar days after delivery and receipt of the invoice.

3. Work Slips and Invoices: The Contractor shall furnish work slips suitable for recording (e.g., - the weight of tube elements, in tons), at the time of each delivery. Accuracy of completed work slips shall be subject to verification by IPSC, who will retain the original copies.

   Invoices for materials or labor outside of the base scope of work shall be submitted to the Contract Administrator. Each invoice shall show the Contract number in addition to the essential information on each delivery covered by the invoice. In all cases, the amount of the applicable sales tax or use tax shall be separately stated on the invoice.

4. Regulations, Permits, Licenses, and Warrants: The Contractor shall comply with all applicable federal, state, and local regulations including, but not limited to, Federal and State OSHA, as said regulations relate to this Contract. In addition, the Contractor shall ensure that all permits, licenses, and warrants relating to the Contract be acquired.

5. Letters to IPSC: All inquiries relating to these specifications prior to award of the Contract shall be addressed to the Buyer.

   All letters pertaining to invoices shall be addressed in accordance with Article 3 of this Division.

   After award of Contract, all letters pertaining to performance of the Contract shall be addressed as follows:

   George W. Cross
   President and Chief Operations Officer
   Intermountain Power Service Corporation
   850 West Brush Wellman Road
   Delta, UT 84624-9546

   Attention: Contract Administrator

   Regarding Contract No: **02-XXXXX**

PART F - DIVISION F1

DETAILED SPECIFICATIONS - SPECIAL CONDITIONS

1. General: Under the terms of the Contract, the Contractor shall furnish and deliver manpower and material as needed by IPSC during the Contract period beginning with date of award of the Contract, hereinafter called the "Contractual Period."

2. Printed Documents: All printed documents including drawings and instruction books, if applicable, shall be in the English language. All units of measurement shall be in the English foot-pound-second system.

3. Indemnity Clause: The Contractor undertakes and agrees to indemnify, hold harmless, and at the option of the Intermountain Power Agency, defend Intermountain Power Agency, Intermountain Power Service Corporation, Los Angeles Department of Water and Power, and any and all of their boards, officers, agents, representatives, employees, assigns and successors in interest from and against any and all suits and causes of action, claims, charges, costs, damages, demands, expenses (including, but not limited to, reasonable attorneys' fees and cost of litigation), judgments, civil fines and penalties, liabilities or losses of any kind or nature, including, but not limited to, violations of regulatory law, death, bodily injury or personal injury to any person, including the Contractor's employees and agents, or damage or destruction to any property of either party hereto, or third persons arising out of the work of the Contractor, or resulting from any negligent act or omission of the Contractor, or anyone directly or indirectly employed by the Contractor, or the Contractor's officers, agents, employees, or subcontractors of any tier, except for the sole negligence of IPA, IPSC, LADWP, or their boards, officers, agents, representatives, or employees.

4. Insurance Requirements: Prior to the start of work, but not later than thirty (30) days after date of the award of Contract, the Contractor shall furnish IPSC evidence of coverage from insurers acceptable to IPSC and in a form acceptable to the Insurance Analyst for IPSC. Such insurance shall be maintained by the Contractor and at the Contractor's sole cost and expense.

   Such insurance shall be provided for the obligations of the Contractor assumed under the Contract. IPA, IPSC, or LADWP will not, by reason of its inclusion under these policies, incur liability to the insurance carrier for payment of premium for these policies.

   Any insurance carried by IPA, IPSC, or LADWP which may be applicable will be deemed to be excess insurance and the Contractor's insurance is primary for all purposes despite any conflicting provision in the Contractor's policies to the contrary.

   Should any portion of the required insurance be on a "Claims Made" policy, the Contractor shall, at the policy expiration date following completion of the work, provide evidence that the "Claims Made" policy has been renewed or replaced with the same limits and terms and conditions of the expiring policy, or that an extended discovery period has been purchased on the expiring policy at least for the Contract under which the work was performed.

   Failure to maintain and provide acceptable evidence of the required insurance for the required period of coverage shall constitute a breach of Contract, upon which the Contract may be terminated or suspended.

a. Workers' Compensation/Employer's Liability

Workers' Compensation Insurance covering all of the Contractor's employees in accordance with the laws of any state in which the work is to be performed and including Employer's Liability Insurance, and as appropriate, Broad Form All States Endorsement, Voluntary Compensation, Longshoremen's and Harbor Workers' Compensation, Jones Act, and Outer-Continental Shelf coverages. The limit for Employer's Liability coverage shall be not less than $1 million each accident and shall be a separate policy if not included with Workers' Compensation coverage. Evidence of such insurance shall be an endorsement to the policy providing for a thirty (30) day prior written notice of cancellation or nonrenewal of a continuous policy to IPSC, by receipted delivery, and a Waiver of Subrogation in favor of IPSC, IPA, and LADWP, its officers, agents, and employees. Workers' Compensation/Employer's Liability exposure may be self-insured provided that IPSC is furnished with a copy of the certificate issued by the state authorizing the Contractor to self-insure. The Contractor shall notify IPSC, by receipted delivery, as soon as possible of the state withdrawing authority to self-insure.

b. Commercial General Liability

Commercial General Liability with Blanket Contractual Liability, Products and Completed Operations, Broad Form Property Damage, Premises and Operations, Independent Contractors, and Personal Injury coverages included. Such insurance shall provide coverage for total limits actually arranged by the Contractor, but not less than $5 million Combined Single Limit and be specific for this Contract. Umbrella or Excess Liability coverages may be used to supplement primary coverages to meet the required limits. Evidence of such coverages shall be on IPSC's Additional Insured Endorsement Form or on an endorsement to the policy acceptable to IPSC and provide for the following:

(1) To include IPA, IPSC, LADWP, and their officers, agents, and employees as additional insured with the Named Insured for the activities and operations under the Contract.

(2) That the insurance is primary and not contributing with any other insurance maintained by IPA, IPSC, or LADWP.

(3) A Severability-of-Interest of Cross-Liability Clause such as: "The policy to which this endorsement is attached shall apply separately to each insured against whom a claim is made or suit is brought, except with respect to the limits of the company's liability."

(4) That the policy shall not be subject to cancellation except after written notice to IPSC, by receipted delivery, not less than thirty (30) days prior to the effective date thereof.

(5) A description of the coverages included under the policy as required by the Contract.

c. Commercial Automobile Liability

Commercial Automobile Liability covering the use of owned, nonowned, hired, and leased vehicles for total limits actually arranged by the Contractor, but not less than $1 million Combined Single Limit. Such insurance shall include Contractual Liability coverage. The method of providing evidence of insurance and requirements for additional insureds, primary insurance, notice of cancellation, and Severability-of-Interest shall be the same as required in the Commercial General Liability Section of these terms and conditions.

d. Professional Liability

The Engineer shall provide Professional Liability Insurance with Contractual Liability coverage included, covering the contractor's liability arising from errors and omissions made directly or indirectly during the execution of this contract and shall provide coverage for the total limits actually arranged by the contractor, but not less than $5 million, Combined Single Limit. Such policy shall be maintained for not less than three (3) years after the date of final acceptance and completion of the work performed under this contract. Evidence of such insurance shall be in the form of a special endorsement of insurance and shall include a Waiver of Subrogration against the Intermountain Power Agency, the Intermountain Power Service Corporation and the Los Angeles Department of Water and Power, and their officer, agents and employees.

e. Other Conditions.

(1) Failure to maintain and provide acceptable evidence of the required insurance for the required period of coverage shall constitute a major breach of Contract, upon which IPSC may immediately terminate or suspend the Agreement, or at its option, procure such insurance and submit a claim against Contractor's Performance Bond, deduct the cost thereof, including an administrative charge of two (2) percent, from any monies due the Contractor, or shall be immediately reimbursed by the Contractor for such costs upon demand.

(2) The Contractor shall be responsible for all subcontractors compliance with these insurance requirements.

5. Transportation: All shipments of hazardous materials under this Contract shall be handled in accordance with current U.S. Department of Transportation regulations and other applicable federal, state, and local laws and regulations.

6. Safety: The Contractor agrees it is familiar with the risks of injury associated with the work, has reviewed the work to be performed, inspected the job site with an IPSC

representative, and has determined that no unusual or peculiar risk of harm exists with regard to the work to be performed at the job site.

The Contractor further agrees it shall, at all times, provide at the job site a competent supervisor(s) familiar with IPSC's and the industry's safety standards to ensure compliance with all federal, state, and local regulations pertaining to safety, including, but not limited to, Federal and State OSHA, as said regulations relate to the work to be performed under the Contract. Although IPSC assumes no responsibility to oversee or supervise the work, IPSC reserves the right to review safety programs and practices and make recommendations to the Contractor. Any such review or recommendation by IPSC will not increase IPSC's liability or responsibility and shall not relieve the Contractor from providing a safe work environment and complying with legal requirements.

The Contractor shall comply with IPSC's safety and equipment requirements prior to starting work. Worker protective clothing, which includes, but is not limited to, hardhats, safety glasses, safety shoes, gloves, respirators, earplugs, safety harnesses, and face shields shall be provided by the Contractor.

Prior to starting work, all of the Contractor's personnel shall attend a safety orientation taught by a representative of IPSC. At the Contractor's option, a supervisor may attend the orientation taught by IPSC, then present the orientation to the remainder of the Contractor's personnel. In this case, a roll shall be given to IPSC which lists each person who received the orientation and the date it was received.

7. Security Compliance: The Contractor and its employees, agents, representatives, and/or subcontractors, while performing work or services on IPSC premises, shall fully comply with all fire prevention, security, and safety rules in force at IPSC. The Contractor and its employees, agents, representatives, and/or subcontractors personnel and vehicles are subject to a random inspection of his/her person and/or vehicle upon entering, working on, and departing the plant site.

   The Contractor will be directed to specified areas for parking vehicles and equipment by the Contract Administrator. Certain areas of the IPSC plant site are restricted to IPSC vehicles only. Exceptions to the parking restriction will be made on an as needed basis through the Contractor's respective Contract Administrator. The Contractor shall make its employees, agents, representatives, and/or subcontractors aware of all areas that are subject to restricted parking.

8. Material Safety Data Sheets: The Contractor shall furnish a Material Safety Data Sheet (MSDS) for all hazardous materials furnished under this Contract. The MSDS shall be furnished to IPSC on, or prior to, the date of the first delivery of the materials or equipment.

   If the specifications require that the Contractor furnish instruction books, the Material Safety Data Sheets shall also be included in such books.

9. Liquidated Damages: The Contractor shall be penalized for substandard performance, in delivery and installation, in accordance with the following provisions:

a. If the Contractor is not prepared to proceed with the approved Installation Plan at the start of each respective outage, the Contractor shall pay for all costs associated with mobilization and demobilization incurred by the Contractor plus a boiler performance penalty of $100,000, representing a small fraction of the cost incurred by the Owner.

b. For each day, at the start of each respective outage, that the Contractor is unprepared to execute the approved Installation Plan, the Contractor shall be assessed a penalty of $100,000.00, up to a maximum of 10 days or $1,000,000.00 . .

c. For each day or portion thereof, that the Contractor exceeds the 'Boiler Released to Operations' date specified in the contract Installation Plan, the Contractor shall be penalized $100,000.00. The maximum penalty for extending a single unit outage shall be 10 days or $1,000,000.

d. The Contractor shall be allowed to avoid one day of penalty associated with exceeding the 'Boiler Released to Operations' date, should such occur, if all materials and equipment are received and staged at the site in accordance with the approved Installation Plan, at least one week prior to the outage start date. All boiler tubing and must be received at the site at least two weeks prior to the outage start date in order to take advantage of this incentive.

e. For each tube or weld failure (tube leak) incident occurring at a Contractor installed tube or weld within two years of installation, the Contractor shall pay to IPSC the sum of $10,000.

10. Contract Termination: IPSC reserves the right, by giving written notice to the Contractor, to terminate the whole or any part of this Contract at IPSC's convenience, whether or not the Contractor is in default. In the event of termination, IPA will pay the Contractor reasonable and proper termination costs; however, if the Contractor's Proposal includes cancellation charges, payment for termination costs shall not exceed the cancellation charges set forth therein. Termination of the work shall not constitute the basis for a claim for damages or loss of anticipated profits and the Contractor hereby releases IPA, IPSC, and LADWP from any such claim.

    The Contractor shall, after consultation with IPSC, take all reasonable steps to minimize the costs related to termination. The Contractor shall provide IPSC with an accounting of costs claimed, including adequate supporting information and documentation and IPSC may, at its expense, audit the claimed costs and supporting information and documentation.

11. Typical Site Weather Conditions:
    The average daily temperature at the plant site is 90°F in summer and 45°F in winter. During winter it is common for the temperature to stay below 10°F for up to two (2) weeks. Winter snow is a common occurrence and can stay on the ground for extended periods. The boilers are located indoors but are open to ambient conditions during outages. The Contractor shall come prepared for temperature extremes.

PART F - DETAILED SPECIFICATIONS

DIVISION F2 - DETAILED REQUIREMENTS

1. General: The scope of this contract includes the design, procurement, fabrication, delivery, installation and start-up of modifications to the Intermountain Generating Station (IGS) Units 1 & 2 Steam Generators.

   a. These contract modifications shall provide for a continuous boiler rating of 6,900,000 lbs/hr output at 1005°F superheat and 1005°F reheat temperature under normal operating conditions. These modifications shall also include an overfire air system capable of providing a reduction in NOx emissions of 15% and consistent NOx emissions of less than 0.40 lbs/MMBTU under all operating modes. See Performance Guarantees, Section 11.

   b. Within the design phase of the work, the Contractor shall review all operational impacts on associated equipment and systems such as fans, burners and dampers. Any concerns regarding operating limitations or increase power demands noted within the modeling/design phase shall immediately be brought to the attention of the Contract Administrator.

   c. A primary focus of this contract shall be the optimization of the work to occur during Unit offline hours. Detailed planning of the contract work scope shall include a level of redundancy in materials, equipment and manpower to ensure that guaranteed schedules are achieved.

2. Project Scope: The successful bidder shall provide and complete the following work:

   a. Boiler Model:
   The Contractor shall prepare and utilize a representative Boiler Model to determine the proper design, arrangements, operating guidance and operational impact associated with the boiler modifications within this contract. Among the operational impacts evaluated shall be:

   - Superheat Temperature & Pressure
   - Reheat Temperature
   - Furnace Exit Gas Temperature
   - Economizer Exit Gas Temperature
   - Generation of Oxides of Nitrogen
   - Furnace Heat Absorption and Cleanliness
   - Superheat & Reheat Attemperator Sprays
   - Carbon Monoxide Generation
   - Burner Metal Temperatures both In-service & Out-of -service

   A complete set of model inputs and results of the various model runs shall be provided to the Owner as part of the Owners design review of this project.

b. Platen Superheat Extension:
The Contractor shall design, fabricate and install additional platen superheat surface on both Units 1 & 2, to maximize both reheat and superheat temperature support while maintaining boiler efficiency. The base design case shall consist of an 8 foot extension of the platen superheater element loops.

Unless otherwise specified or recommended by the bidder, the extensions shall be installed at a single cut line located 18 in. above the upper, inner loop tube of each platen element. This will result in an approximate vertical section length on the outer loop tube of each element of 13.5 ft or a actual element extension of 8 ft.. The design shall include appropriate modifications to the steam cooled alignment tubes, additional alignment castings and all other provisions for ensuring reliable, long-term operation of the platen superheaters.

The platen extension design shall include a complete assessment of the adequacy of the existing structural support systems, metallurgy, seismic, environmental impacts, boiler efficiency and other operational impacts of the associated boiler modifications. The Contractor shall perform a specific assessment of the adequacy of the present sootblowing system and provide recommendations for sootblowing system enhancements where advisable. Assessment of and provisions for quantifying and minimizing tube wastage and fouling concerns shall be included within the detailed design.

c. Overfire Air System:
The Contractor shall design, fabricate and install an overfire air system on both Units 1 & 2., that is capable of reducing overall NOx by 15% on each unit and allow for operation at or below 0.40 lbs/MMBTU NOx under normal operation. See Performance Guarantees, Section 11.

Within the design phase of the work, the Contractor shall review all operational impacts on associated equipment and systems such as fans, burners and dampers. Anticipated operating modes, recommended operating methods, and allowable equipment limits shall be clearly defined for the affected systems.

The Contractor shall provide a complete set of drawings for the overfire air modifications including details of the type, quantity and manner of interface for each existing system or piece of equipment affected by the contract modifications. Drawings shall include item by item detail of instrumentation, piping, power and any other inter-ties with or connections to plant systems.

This work includes all access, disassembly, insulation removal, scaffolding, waterwall window construction, OFA port installation, duct installation, air balancing hardware installation, insulation/lagging replacement. The Overfire Air System shall be designed and constructed with standard sized components and assemblies. This is to allow for retrofit of additional overfire air components or assemblies into the Unit 1 & 2 boilers at a later date in the case where the bidder proposes something less than a full OFA system at the present time.

d. Alignment of Intermediate Superheat:
The Contractor shall install owner provided, split-ring, alignment castings, as replacements in the locations of the original castings on the intermediate superheat pendants. This work consists of aligning the existing tube elements and installing the castings at three elevations on each vertical section of the intermediate superheat pendants. This is a total of approximately 250 castings.

e. Insulation and Lagging:
The Contractor shall provide and install replacement insulation anchors, insulation, lagging and all other materials required for complete restoration of any and all boiler external surface removed or disturbed during or resulting from contract work. The Contractor shall replace or install insulating materials of a quality meeting or exceeding the insulation system currently in use on the respective boiler and system components.

f. Access Provisions:
The Contractor shall design, furnish and install a multi-level access scaffolding system for installation in the boiler furnace in 4 days or less. Removal of the scaffold from the boiler shall occur in 3 days or less.

The scaffold system shall be designed to allow access for work on all burner levels, OFA port installation, general inspection and repair of possible eroded areas around all wall blowers and full platform access at the arch nose elevation. This includes 4', full perimeter walkway access at eight separate levels and a full platform at the arch nose elevation.

Above the nose platform, scaffold shall be provided for full access to platen tube cut/weld line on both sides of each element. Scaffold shall be designed for convenient, standing access to all platen extension welds.

Scaffold hardware shall also be provided for access to all approximate 250 split ring castings on the intermediate superheat pendants.

The Owner may elect to provide the boiler internal scaffold from other sources. In this case, the Owner will consult directly with the Contractor regarding access requirements and schedule coordination. All responsibilities for access hardware shall be clearly set forth in the approved Installation Plan.

The contractor shall provide any replacement membrane wall material/sections associated with additional access requirements or other material arising out of the contractors Installation Plan. Accessways installed through the boiler wall membrane shall be done in such a way as to maximize productivity and minimize total outage time required. Extent of membrane wall prefabrication shall be detailed in the Installation Plan.

All scaffold and access hardware shall be OSHA approved structures. The furnace scaffold structure shall be thoroughly reviewed and stamped by an experienced, professional, structural engineer licensed in the State of Utah.

The Owner shall be allowed access to scaffold and other access provisions in any areas required. This work will be coordinated through the Contract Administrator or designee in a manner aimed at minimizing contractor schedule impacts. Scheduled Owner work within the areas of the contract work shall be outlined within the approved Installation Plan.

g. Technical Support:
The Contractor shall consult with the Owner throughout the design development process allowing the Owner to participate in the selection process of preferential items or common industrial equipment required within the design. Bidders shall include the names and direct dial phone numbers of the lead project design engineers in each area of expertise, in the bid package. Where possible the name and number of the assigned site construction coordinator should also be provided. All technical advisory personnel assigned to support the Owner within this project shall have a minimum of 10 years experience in the issues to be addressed.

During construction and startup the Contractor shall provide full service technical support in all areas of expertise required for successful startup and tuning of the boiler. This shall include technical support in proper positioning, tuning, operation and control of the convection pass bias dampers.

Bidders shall include a minimum of 2 weeks of support following startup to ensure stable operation. In addition, bidders shall include at least one additional week (including travel and board) at the site for two people to witness and participate in the full load operational testing. Should extended problems arise as a direct result of the contract modifications, the Contractor shall provide whatever level of support is required to address the problems, in a timely manner.

h. Clean-up and Demobilization:
The Contractor shall be responsible to maintain his work areas in an organized and safe manner throughout the execution of the Installation Plan. IPSC shall retain the right to assess and require correction of any areas or situations it deems as impacting ongoing operations and maintenance. Waste material produced during a shift shall be disposed of by the end of the following shift.
At the conclusion of each outage, the Contractor shall ensure that all work areas associated with this contract are restored, replaced and/or cleaned in a manner similar in appearance to that found prior to the outage.

3. Schedules: The Unit 1 Outage is currently scheduled to begin on March 1, 2003 and end on March 28, 2003. The Unit 2 Outage is currently scheduled to begin on February 28, 2004 and end on March 26, 2004.

   a. All bidders shall provide a guaranteed installation schedule as part of the proposed Installation Plan submitted with each bid package.

   b. The proposed Installation Plan shall be developed to ensure completion of all work inside the boiler within a maximum of 26 days. This 26 day period shall include 4 days for installation of the boiler internal scaffolding and 3 days for removal of the same.

   c. Work not requiring the unit to be off-line, such as mobilization, staging, boiler enclosure structural access work, demobilization etc. shall be clearly identified on the proposed Installation Plan and can be coordinated outside this outage window, with approval of the Contract Administrator.

   d. The bidders shall provide a schedule of costs associated with an IPSC scheduled delay of the outage start date in one week increments up to a one month. These costs shall be based on notification from IPSC 1 month prior to the scheduled outage start dates and a second schedule based on notification from IPSC 1 week prior to the scheduled outage start dates.

   e. Unless otherwise noted in these Specifications, IPSC facilities and equipment shall not be used in support of this work. To prevent delays, caused by equipment breakdown, the Contractor shall provide spare tools and equipment at the jobsite in reasonable quantities in anticipation of equipment failures.

4. Installation : Each bidder shall prepare and provide, with each bid package, a proposed Installation Plan showing project progress on a daily basis beginning with initial equipment delivery and ending with site clean up and exit.

   a. The proposed Installation Plan, submitted with the bid package, shall be the basis for development of the approved Installation Plan forming a part of the eventual contract governing this work. The approved Installation Plan shall be used as the basis for instituting mid-outage resource corrections and for calculating any penalties associated with completion of the work scope.

   b. The proposed Installation Plan shall include detailed information regarding each task within the contract scope, including:

      - Equipment and Material Delivery
      - Equipment Mobilization and Assembly
      - Manpower Loading Throughout the Contract
      - Scaffold Installation Plan
        - Scaffold Erected - Guaranteed Date
        - Scaffold Removed - Guaranteed Date

- Boiler Pendant Split Ring Casting Replacement
- Platen Loop Removal and Extension
- Overfire Air Port Window Removal and Port Installation
- NDE Requirements
- Combustion Air Ducting Modifications
- Any Windbox or Burner Work Required by OFA Design
- Boiler Insulation Specifications
- Boiler Released to Operations - Guaranteed Date
- Equipment Disassembly
- Material Equipment Removal and Area Clean-up

c. The proposed Installation Plan, to be included as part of the submitted bid, shall include estimates of all required on-site services, with clear identification of each request for service to be provided by IPSC. These estimates shall include power service requirements for running all electrical equipment and compressed air requirements. Authorization for connection to and use of requested power, compressed air or other on-site services must be coordinated and approved by the IPSC Contract Administrator.

d. At least two (2) months prior to mobilization to the site, the successful bidder shall provide a detailed material 'Laydown Plan' for coordination of area utilization and access. The Laydown Plan shall address staging and temporary storage requirements for all associated materials and equipment in order to minimize interference with ongoing plant operations and outage work. This plan shall be submitted to and approved by the Contract Administrator prior to receiving any contract materials, equipment or craft personnel on-site for the outage work.

e. Contractor shall provide and utilize two certified welders over and above the minimum number required to meet the guaranteed schedule specified within the proposed Installation Plan. Any welder found to produce more than one substandard weld within a 7 day period shall be permanently removed from code welding work for the duration of the job. Determination of substandard weld quality shall be the responsibility of the Contract Administrator or designee.

5. <u>Applicable Codes and Standards</u>:

The work performed within these specifications shall adhere to the applicable portions of the latest published revision of the following codes and standards:

- ASME American Society of Mechanical Engineers
- NBIC National Board Inspection Code
- AWS American Welding Society
- OSHA Occupational Safety and Health Administration
- ASNT American Society for Nondestructive Testing
- Contractor's Utah Jurisdiction Approved R Stamp Program

7. Safety: The Contractor shall be responsible to provide and manage an acceptable safety program. For additional information see Division F1, Page F1-3, Article 6.

   a.. The Contractor shall provide a full-time Safety Representative. The Safety Representative shall act as the point of contact for all safety-related issues and may be assigned additional duties.

   b.. The Contractor shall provide copies of written safety policies/plans to the Contract Administrator one (1) month prior to beginning work. These include, but are not limited to, Respiratory Protection, Confined Spaces, and Hazard Communication.

   c. Prior to flame cutting or welding in any location, the Contractor shall first obtain a Hot Work Permit. This permit will be coordinated by the Contract Administrator or designee. The permit lists mandatory safety precautions which shall be taken before, during, and after hot work.

   d. The Contractor shall ensure that its employees perform work in accordance with all applicable federal, state, and local safety and health regulations. The IPSC Safety Section personnel will periodically monitor the job site. If violations are noted, they will be reported to the Contractor's onsite Supervisor and the Contract Administrator for appropriate action.

   e. The following table is a list of anticipated safety hazards and personal protective equipment needed in the contract area. This must not be considered a complete listing of all potential hazards. The Contractor shall provide appropriate personal protective equipment to its employees to protect against these hazards and others as they are identified :

Hazard	Needed Safety Equipment
Hazardous noise.	Earplugs and/or muffs.
Toxic fumes and/or vapors from welding, grinding, or solvent type cleaning.	Preparing for proper working atmosphere in and around the boiler requires specific preparation by the contractor.
Head injuries from falling material or bumps.	Hard hats.
Burns from welding and cutting.	Gloves, long sleeve shirts, and welding leathers.
Foot injuries from dropped tools or equipment.	Steel-toed boots.
Eye and face injuries.	Safety glasses and face shields.

8. Quality Assurance/Quality Control:

a. The Owner reserves full access rights for quality assurance inspections of ongoing work. A non-binding schedule identifying the anticipated, approximate number of random Q/A inspections in each area shall be prepared by the Owner and included within the approved Installation Plan.

b. The Contractor shall provide, within the proposed Installation Plan, a Quality Control Plan, identifying the procedures and acceptance criteria to govern the work. This job specific quality control plan shall detail the number and type of examinations to be performed during installation to ensure the long-term integrity of all pressure boundaries and structural connections.

c. The successful bidder shall provide all required NDE personnel in support of the Contractor's R Stamp Program and as detailed in the approved Installation Plan. These personnel will be trained and certified in accordance with ASNT standards, with at least 5 years in the applicable technique.

d. The Contractor shall provide to the Owner a copy of all code documentation required including but not limited to:
   NDE Certifications
   R Forms
   Repair Plans
   Welder Certifications
   Procedure Qualifications
   NDE Reports
   Material Test Reports

e. The Contractor shall submit certified weld procedures and welder qualification records for each welder employed, to the IPSC Contract Administrator prior to beginning work.

f. A substandard weld shall be defined as any weld declared substandard in the opinion of the IPSC Contract Administrator or designee. The ASME and AWS codes will form the basis of the acceptability determination.

g. Completed welds shall be smooth and free of undercutting, cavities, depressions, cracks, surface porosity, weld craters, overlaps, and abrupt ridges. All welds shall meet the specifications of the applicable sections of AWS and ASME Section I.

9. Available On-Site Services: Unless otherwise arranged, in writing, with the Contract Administrator, on-site services shall be provided in accordance with this section. Services not covered in this section shall be provided by the Contractor.

a. IPSC will make potable water, compressed air (small volume only), and electricity available at 460V and 120V. Connections to IPSC electric or water systems shall be made only by IPSC employees unless approved otherwise in writing for each specific location. The Contractor shall identify all service connection requirements within the proposed Installation Plan.

b. The Contractor shall provide enough sanitary facilities for its employees. Contractor employees are prohibited from using the permanent restroom facilities at the site.

c. Equipment and material staging requirements shall be clearly detailed within the successful bidders site Laydown Plan submitted to the Contract Administrator at least two months prior to the outage start date. Actual placement of materials and equipment shall be coordinated with the Contract Administrator.

d. The Contractor shall maintain a clean work space. The Contractor shall clean the work site at least daily. This includes, but is not limited to, picking up trash, sweeping, and washing the area as necessary, straightening cords and hoses, organizing tools and equipment, and emptying trash receptacles. IPSC will provide trash collection containers (dumpsters) for the Contractor's use, outside the generation building at ground level. IPSC will empty these containers as needed.

e. IPSC will provide general fire protection and first aid services. Provisions for local fire extinguishing , such as weld slag induced fires, shall be provided by the Contractor. All workplace injuries shall be reported to the IPSC First Aid Clinic and the Contract Administrator.

g. IPSC will not provide office or administrative space or off-site telephone service to the Contractor; however, IPSC will make an on-site telephone line available to the Contractor at a specific, office-trailer-ready location, if requested. The Contractor shall make its own arrangements for "off-site" and long distance phone service.

10. Site Security and Access: The Intermountain Generating Station has an existing fence and security system to restrict access to the site. However, the construction site will not be fenced separate from the rest of the plant site and will therefore be accessible by all those approved for site access. It is the contractors responsibility to protect themselves and their equipment and tools from theft and vandalism as they deem necessary. IPSC will not be responsible for any theft or damage incurred by the contractor.

a. Only vehicles owned and insured by the Contractor or an approved sub-contractor will be allowed inside the plant fence perimeter. All other contractor employees shall park their vehicles outside the fence perimeter at Guard Post #1 located southwest of Unit 2. The contractor shall be responsible for transport of the employees to and from Guard Post #1 and the jobsite. The contractor shall not use the back of trucks for employee transport.

b. All contractor employees will be given security badges by the owner and those badges shall be displayed each day to gain admittance to the plant site. All security badges shall be returned to the security contractor when the employee terminates their work at this site. All contractor vehicles will also receive parking stickers from the security contractor allowing entrance to the plant site. Temporary badges and parking stickers are available for intermittent contractor employees and vehicles.

11. Shipping, Receiving, Handling and Storing:

a. Shipping: The Contractor shall ensure that all materials and equipment are securely prepared for shipment to prevent damage and or deterioration. All pressure parts shall be coated with a light color rust inhibiting coating prior to shipment to allow for ready identification and correction of damaged material.

Tube ends shall be fully prepared for installation prior to shipment and shall be capped or otherwise protected from damage during shipment. Tubing shall be shipped and stored with means for preventing oxidation/corrosion of internal and external surfaces.

b. Receiving: Upon arrival at the plant site, the Contractor shall examine all shipments for shortages, discrepancies or damage. The Contractor shall prepare a report itemizing the material received and submit to the Contract Administrator.

c. Handling: The Contractor shall be responsible for any damage to equipment and materials until final acceptance of the work. The Contractor shall be responsible for arranging the unloading all carriers promptly and shall pay any demurrage incurred. Materials shall be handled with due care to prevent damage or loss.

d. Storage: All equipment, materials, and supplies not immediately incorporated in the work shall be placed in storage. Storage areas will be allocated and assigned by the Project Manager but, will be in general area of the work. The storage areas shall be kept clean and orderly at all times.

The Contractor shall temporarily connect the motor space heaters for the fan motors to a 120 volt source while in storage and construction and until a permanent source is available.

12. Performance Guarantees: Significant weight will be applied to the form and type of the performance guarantees offered within each bid. Of particular interest to IPSC are the performance parameters associated with operation at 950 Megawatts gross generation (6.75 MMlbs/hr steam flow). These include:

a. Total NOx output of 0.40 lbs/MMBTU or less and an overall reduction of 15%. Current maximum average of 0.45 lbs/MMBTU.

b. Superheat and reheat temperatures as well as NOx emissions must remain within the contract stated acceptable ranges throughout the test.

c. Impact on average unburned carbon (LOIs) and carbon monoxide (CO) concentrations within the boiler.

d. The above operational guarantees shall be verified in a steady state operational test within 30 days of installation. Steady state operation shall be defined as stable and reliable operation at and within the following operating conditions and ranges for a period of at least 7 days:
-7 pulverizers in service (E and G Pulverizers alternately out-of-service).
-Excess air to be controlled between 2.5 to 3.2%.
-Superheat and convection surfaces maintained at 80-85% cleanliness
-Boiler tube maximum allowable metal temperatures must not be exceeded.
-Turbine throttle pressure of 2375 psi.
-Furnace cleanliness maintained at 85-90% actual cleanliness.
-Superheat attemperator spray flow at or above 50,000lbs/hr
-Reheat attemperator spray flow at 0 lbs/hr

e. Should the Contractor fail to achieve the above stated operating conditions, the contractor shall, as station operating schedules allow and at his own expense, provide all required expertise, material, equipment and labor to achieve the above specified operating parameters.

INTERMOUNTAIN POWER SERVICE CORPORATION

X REQUISITION FOR CAPITAL EQUIPMENT

♦ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Modification of Boiler for 950MW operation.

Date:	
Req./PA No:	181220
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Babcock Borsig
5 Neponset Street
Worcester, MA 01606
Attn: Kevin Davis (508)854-3818

Account No. 1SGX-402
Work Order No. 02-60456
Project No. IGS02-14

Qty	Unit	Description: Noun Adjective Catalog # Seller or Manufacturer	Unit Cost	Extension
1	job	Modifications, Boiler, as detailed in	$8,600,000.00	$8,600,000.00
		specification 02-45576, (copy attached). Work		
		to include modeling, design, materials,		
		fabrication, mobilization, installation &		
		demobilization. The total cost shown at right		
		is the total of all phases bid. Award of		
		site work on the second unit is contingent		
		upon successful installation of the first unit.		
		TOTAL ESTIMATED COST		$8,600,000.00

Remarks: Contract needs to be awarded by Sept 13 in order to avoid outage schedule impacts.

Delivery requested by [Date] 8/26/02 Originator James Nelson

Dept. Mgr/Supt. Date Station Manager Date Operating Agent Date

IP7_036886

INTERMOUNTAIN POWER SERVICE CORPORATION

X REQUISITION FOR CAPITAL EQUIPMENT

♦ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Modification of Boiler for 950MW operation.

Date:	
Req./PA No:	181223
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Babcock Borsig
5 Neponset Street
Worcester, MA 01606
Attn: Kevin Davis (508)854-3818

Account No. 1SGX-402
Work Order No. 02-60456
Project No. IGS02-14

Qty	Unit	Noun / Description Adjective / Catalog # / Seller or Manufacturer	Unit Cost	Extension
1	job	Services, Preliminary Engineering , associated	$20,000.00	$20,000.00
		with boiler modifications by Babcock Borsig.		
		(quote no. 501080). Funds on this order are to		
		accounted as part of, not in addition to,the cost		
		the primary order for design and supply of boiler		
		modifications under specification 02-45576 in the		
		event that such is placed. The preliminary		
		engineering work shall be completed under the		
		terms & conditions identified with spec 02-45576.		
		Work covered by this requisitions will include		
		engineering review of existing IGS system equip-		
		ment, boiler model development work and prelim-		
		inary design of boiler modifications.		
		TOTAL ESTIMATED COST		$20,000.00

Remarks: This requisition shall be null and void upon execution of a primary contract covering this work.

Delivery requested by [Date] 8/26/02 Originator James Nelson

Dept. Mgr/Supt.	Date	Station Manager	Date	Operating Agent	Date

IP7_036887

INTERMOUNTAIN POWER SERVICE CORPORATION

☒ REQUISITION FOR CAPITAL EQUIPMENT

☐ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Structural alterations for simplified overfire duct design.

Date:	
Req./PA No:	185830
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Black & Veatch
11401 Lamar Ave
Overland Park, KS 66211

Account No. 1SGX-201
Work Order No. 02-60456
Project No. IGS02-14

Qty	Unit	Description: Noun Adjective Catalog # Seller or Manufacturer	Unit Cost	Extension
1	job	Services, Engineering, Structural Alterations	$11,000.00	$11,000.00
		associated with the overfire air duct design		
		simplification. Work to include design of		
		structural alterations for simplification of duct		
		routing at the ninth level of Unit 1 & 2		
		boiler enclosures. Detailed design of the		
		south corner sections at ninth level is		
		contingent on approval of the refined conceptual		
		estimate in that location.		
		Drawings sufficient for procurement and		
		fabrication work will be provided by 12/11/02		
		as part of this work.		
		TOTAL ESTIMATED COST		$11,000.00

Remarks:

Delivery requested by [Date] 12/11/02 Originator James Nelson

Dept. Mgr/Supt. Date Station Manager Date Operating Agent Date

IP7_036888

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

SECTION I - EQUIPMENT LIST

Item	Description	Project ID	Elev./Column&Row /Routine	Model, Size, or Diameter	ucm-row-col-pt
1.	SW OFA Header Inlet Dmpr Drive	2SGB-CDR-0169	4803'	Jordan 5220	
2.	SE OFA Header Inlet Dmpr Drive	2SGB-CDR-0170	4803'	Jordan 5220	
3.	NW OFA Header Inlet Dmpr Drive	2SGB-CDR-0171	4803'	Jordan 5220	
4.	NE OFA Header Inlet Dmpr Drive	2SGB-CDR-0172	4803'	Jordan 5220	
5.	SW OFA 2/3 Dmpr Drive	2SGB-CDR-0173	4803'	Jordan 5220	
6.	SE OFA 2/3 Dmpr Drive	2SGB-CDR-0174	4803'	Jordan 5220	
7.	NW OFA 2/3 Dmpr Drive	2SGB-CDR-0175	4803'	Jordan 5220	
8.	NE OFA 2/3 Dmpr Drive	2SGB-CDR-0176	4803'	Jordan 5220	
9.	SW OFA 1/3 Dmpr Drive	2SGB-CDR-0177	4803'	Jordan 5220	
10.	SE OFA 1/3 Dmpr Drive	2SGB-CDR-0178	4803'	Jordan 5220	
11.	NW OFA 1/3 Dmpr Drive	2SGB-CDR-0179	4803'	Jordan 5220	
12.	NE OFA 1/3 Dmpr Drive	2SGB-CDR-0180	4803'	Jordan 5220	
13.	SW OFA Header Inlet Flow Transmitter	2SGB-FT-0155	4803'	Internal to CAMS	
14.	SE OFA Header Inlet Flow Transmitter	2SGB-FT-0156	4803'	Internal to CAMS	
15.	NW OFA Header Inlet Flow Transmitter	2SGB-FT-0157	4803'	Internal to CAMS	
16.	NE OFA Header Inlet Flow Transmitter	2SGB-FT-0158	4803'	Internal to CAMS	
17.	OFA S Common Inst CAB	2SGB-CAB-0009	4803'	31"x24"x72"	
18.	OFA N Common Inst CAB	2SGB-CAB-0010	4803'	31"x24"x72"	
19.	OFA Hdr SW Inlet Flow CAMS CAB	2SGB-CAB-0011	4803'	Air Monitor CAMS	
20.	OFA Hdr SE Inlet Flow CAMS CAB	2SGB-CAB-0012	4803'	Air Monitor CAMS	

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

21.	OFA Hdr NW Inlet Flow CAMS CAB	2SGB-CAB-0013	4803'	Air Monitor CAMS	
22.	OFA Hdr NE Inlet Flow CAMS CAB	2SGB-CAB-0014	4803'	Air Monitor CAMS	
23.	OFA SW Inlet Flow TT	2SGB-TT-109	4803'	Internal to CAMS	
24.	OFA SE Inlet Flow TT	2SGB-TT-110	4803'	Internal to CAMS	
25.	OFA NW Inlet Flow TT	2SGB-TT-111	4803'	Internal to CAMS	
26.	OFA NE Inlet Flow TT	2SGB-TT-112	4803'	Internal to CAMS	
27.	OFA SW Inlet Flow TE	2SGB-TE-1679	4803'	TE in OFA duct	
28.	OFA SE Inlet Flow TE	2SGB-TE-1680	4803'	TE in OFA duct	
29.	OFA NW Inlet Flow TE	2SGB-TE-1681	4803'	TE in OFA duct	
30.	OFA NE Inlet Flow TE	2SGB-TE-1682	4803'	TE in OFA duct	

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

SECTION II - Scope of Work for GSL - Unit 2.

1. Install new wireways:
   a. Wireway on the north side of the 9th level labeled on overview drawing as 2WLC0737 & 2WLC0738.
   b. Wireway 2WLC0739 from 8th to 9th level on south-west corner (from 2TLC0055 to 2TLC0067).
   c. Wireway 2WLC0740 from 8th to 9th level on south-east corner (from 2TLC0054 to 2TLC0059).

2. Install instrument cabling from the control system (Unit 2 - 3rd level, UCM 13, CAB 3, Section A9) to the common cabinets (Unit 2 - 9th level, 2SGB-CAB-0009 and 2SGB-CAB-10) including installation of conduit or tray necessary for connections to cabinets.
   a. Cable Route 1: Control Equipment Room 3rd level to 9th Level south side center.
   b. Cable Route 2: Control Equipment Room 3rd level to 9th Level north side center.

3. Install power cable for drive amplifiers from power panels on 8th level to common cabinets on 9th level including installation of necessary conduit runs not already installed. Note: Common Cabinets will be set in place by the OFA construction contractor.
   a. Cable Route 3: PPL-8 on 8th level to 2SGB-CAB-10 on 9th level north side center.
   b. Cable Route 4: PPL-9 on 8th level to 2SGB-CAB-9 on 9th level south side center.

4. Install power and instrument cable for drives from common cabinets to Jordan drives including installation of necessary conduit runs not already installed.
   a. Cable Routes 13, 14, 17, 18, 21, and 22 on south side.
   b. Cable Routes 15, 16, 19, 20, 23, and 24 on north side.

5. Pre-wire internal wiring to CAMS panels and install at the locations identified by IPSC.
   a. Install/mount temperature transmitter.
   b. Install duplex receptacle and grounding plate.
   c. Mount CAMS panels at designated location in Unit 2 9th Level. Panels include:
      i. 2SGB-CAB-0011 (SW)
      ii. 2SGB-CAB-0012 (SE)
      iii. 2SGB-CAB-0013 (NW)
      iv. 2SGB-CAB-0014 (NE)

6. Install power cable from power panels directly to flow transmitter enclosures including installation of necessary conduit runs not already installed.
   a. Cable Routes 5 and 6: 2APA-PPL-008 (8th level) to SW and NW flow transmitter enclosures.
   b. Cable Routes 7 and 8: 2APA-PPL-009 (8th Level) to SE and NE flow transmitter enclosures.

7. Install instrument cable from common cabinets to flow transmitter enclosures including

installation of necessary conduit runs not already installed.
   a. Cable Routes 9 and 10 on south side.
   b. Cable Routes 11 and 12 on north side.

8. Install thermocouple conduit and cables from flow transmitter enclosures to thermocouples mounted on OFA ducts.
   a. Cable Routes 25 and 26 on south side.
   b. Cable Routes 27 and 28 on north side.

9. Install instrument cable (single pairs, twisted/shielded) between Coordinated Control System (CCS) cabinets through the wiring gallery.
   a. Cabinet 2COA-CAB-0003 (A3-Section A9) through wiring gallery up into cabinets 2COA-CAB-A3 (UCM7), 2COA-CAB-A1 (UCM8), 2COA-CAB-A4 (UCM10), and 2COA-CAB-A2 (UCM11) on the Control Level.

   b. Reference drawings 2COA-K2805A, 2COA-K2806B, 2COA-K2807A, 2COA-K2808A, and 2COA-K2810 to terminal block lay out.

   c. Reference drawing 1EEC-E3515 for locations.Electrical cable and conduit Installation - Addendum to Scope of Work.

10. Note: See Section III and "Attachment 3", sections 3B - 3D for require practices and standards for installation, labeling, grounding, etc.

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

SECTION III - Required Practices and Standards

All work shall be completed in accordance with applicable NEC, NFPA, and NEMA standards. Additional requirements and information are listed below:

- Cable and Tray Installation, Idendification, and Labeling:
  - See drawing 1UUU-K2000B for drawing and wiring identification codes and standards
  - Cable Pans, Trays, Wireways, and Conduit are identified as follows:
    Gallery Cable Pans = uWPC#### : u=unit number, WPC=wiring pan, ####=pan id#
    Cable Trays = uTLa#####: u=unit number, T=tray, L=600V (or less), z####=tray id#
    Wireway = uWLz####: u=unit number, W=wireway, L=600V (or less), z####=wireway id#
    Conduit = uRLz####: u=unit number, R=conduit, L=600V (or less), z####=conduit id#

- Wiring Installation:
  Wiring shall be completed in accordance with the specifications and standards identified in Attachment 3D. For general information the following notes are highlighted:
  - Conductor connectors (section 3D.3.2, p.3D-2):
    - Conductors landed on States Terminal Blocks or other similar type terminal blocks shall be fitted with a ring-lug connector compression fitted on the end of the conductor.
    - Alternatives required for conductors to be landed in a compression type terminal block or other receiver may be used as approved by IPSC.

  - Cable Identification (section 3D.3.8, p. 3D-4):
    - All cables shall be tagged or labeled with the cable identification number as determined on drawings provided.
    - Tags or label shall be attached to the cable within the termination cabinet.
    - Markers for wire and cable circuits shall be of an opaque nylon material 2-1/2" x 3/4" printed or marked with the cable number using a permanent black ink. See section 3D.3.8 for specific requirements.

  - Internal Cabinet Wiring (section 3D.3.8, p3D-4):
    - For wiring installed internal to a cabinet (wiring to and from components entirely within a cabinet), a conductor identification sleeve shall be provided and fastened to each end of each internal conductor.
    - Each sleeve shall be marked with the opposite end destination identification.
    - Conductor identification sleeve shall be of a length of ½ inch or greater and shall be Bradysleeve as manufactured by the W.H. Brady Company or acceptable equal. They shall be permanent and shall be imprinted with a permanent black ink. After inscription, the marking sleeve shall be coated to prevent smudging. Simple adhesive labels are not acceptable.

Conduit, Junction Boxes, and Raceways Installation

Conduit, junction boxes, and raceways shall be installed per the requirements in attachments 3B & 3C.
  - Conduit, couplings, and elbows shall be rigid galvanized steel in accordance section 3C.4.1.2.
  - Final connections to drives shall be made with "Seal-Tite" flexible conduit or other equivalent as approved by IPSC.
  - Conduit, support hangers, and fasteners shall be run and affixed so as to impose the minimal interference into the work and equipment access areas. See page 3C-10 for support and clearance details. Existing conduit, raceways, and trays shall be used wherever possible.
  - Myers hubs with ground lug shall be used for conduit connections.
  - Bond conduit to cable trays with 6AWG bare copper wire. Multi-strand wire for 6AWG and larger is acceptable
  - Ground Cable: Use 2/0 bare copper cable connected to tray grounds.
  - Conduit, wireway, and tray identification and labeling requirements are specified in section 3C.4.3.12, p.3C-11(conduit) and section 3C.5.3.4, p.3C-13 (cable trays). The same shall apply to wireways.
    - All conduit installed shall be clearly identified with its raceway number and clearly visible.
    - Conduit labels shall be a white water proof material imprinted with a permanent black
  - See Attachment 3, section 3C for requirements for installation and securing wireways and conduits.

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

SECTION IV - Cable Routes (New conduit and wireways noted in RED.

Route #	CR1	CR2	CR3	CR4	CR5	CR6
General Desc.	2COA-CAB-3 to 2SGB-CAB-0009	2COA-CAB-3 to 2SGB-CAB-0010	2APA-PPL-008 to 2SGB-CAB-0010	2APA-PPL-009 to 2SGB-CAB-0009	2APA-PPL-008 to 2SGB-2SGB-CAB-0011	2APA-PPL-008 to 2SGB-CAB-0013
Detailed Route Desc.	2COA-CAB-0003 (4718'), 2WPC0011 (4708'), 2WPC0007 (4708'), 2TLA0134 (4730'), 2TLA0095 (4730' - 4743') 2TLA0096 (4743' - 4758') 2TLA0097 (4758' - 4773') 2TLA0098 (4773' - 4788') 2TLC0054 (4788') 2WLC0741 (4788' - 4803') 2SGB-CAB-9 (4803')	2COA-CAB-0003 (4718'), 2WPC0011 (4708'), 2WPC0007 (4708'), 2TLA0134 (4730'), 2TLA0095 (4730' - 4743') 2TLA0096 (4743' - 4758') 2TLA0097 (4758' - 4773') 2TLA0098 (4773' - 4788') *Alt. Route from 2TLA0098 to 2TLC0059 if 2WLC0740 not installed:* *TLA0099 (4803')* *2TLC0074 (4803')* *2TLC0075 (4803')* *2WLC0371 (4803')* 2TLC0054 (4788') 2WLC0740 (4788' - 4803') 2TLC0059 (4803') 2TLC0058 (4803') 2WLC0738 (4803') 2SGA-CAB-10 (4803')	2APA-PPL-008 (4788') 2RLC0682 (4788') 2TLC0055 (4788') 2WLC0739 (4788 - 4803') 2TLC0067 (4803') 2TLC0066 (4803') 2WLC0737 (4803') 2SGA-CAB-10 (4803')	2APA-PPL-009 (4788') 2RLG0683 (4788') 2TLC0054 (4788') 2WLC0741 (4788' - 4803') 2SGA-CAB-9 (4803')	2APA-PPL-008 2RLC0682 (4788') 2TLC0055 (4788') 2WLC0739 (4788 - 4803') 2RLG0672 (4703') 2SGB-FT-0155	2APA-PPL-008 2RLC0682 (4788') 2TLC0055 (4788') 2WLC0739 (4788 - 4803') 2TLC0067 (4803') 2RLG0685 (4803') 2SGB-FT-0157

Route #	CR7	CR8	CR9	CR10	CR11	CR12
Drawing Trace Color						
General Desc.	2APA-PPL-009 to 2SGB-CAB-0012	2APA-PPL-009 to 2SGB-CAB-0014	2SGB-CAB-9 to 2SGB-CAB-0011	2SGB-CAB-9 to 2SGB-CAB-0012	2SGB-CAB-10 to 2SGB-CAB-0013	2SGB-CAB-10 to 2SGB-CAB-0014
Detailed Route Desc.	2APA-PPL-009 2RLG0683 (4788') 2TLC0054 (4788') 2WLC0740 (4788' - 4803') 2RLG0681 (4803') 2SGB-FT-0156 (4803')	2APA-PPL-009 2RLG0683 (4788') 2TLC0054 (4788') 2WLC0740 (4788' - 4803') 2TLC0059 (4803') 2RLG0690 (4803') 2SGB-FT-0158 (4803')	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0055 (4788') 2WLC0739 (4788 - 4803') 2RLG0672 (4703') 2SGB-FT-0155	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0054 (4788') 2WLC0740 (4788' - 4803') 2RLG0681 (4803') 2SGB-FT-0156	2SGB-CAB-10 2WLC0737 (4803') 2TLC0066 (4803') 2TLC0067 (4803') 2RLG0685 (4803') 2SGB-FT-0157	2SGB-CAB-10 2WLC0738 (4803') 2TLC0058 (4803') 2TLC0059 (4803') 2RLG0690 (4803') 2SGB-FT-0158

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

Route #	CR13	CR14	CR15	CR16	CR17	CR18
General Desc.	2SGB-CAB-9 to 2SGB-CDR-0169	2SGB-CAB-9 to 2SGB-CDR-0170	2SGB-CAB-10 to 2SGB-CDR-0171	2SGB-CAB-10 to 2SGB-CDR-0172	2SGB-CAB-9 to 2SGB-CDR-173	2SGB-CAB-9 to 2SGB-CDR-174
Detailed Route Desc.	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0055 (4788') 2WLC0739 (4788 - 4803') 2TLC0067 (4803') 2RLG0673 (4803') 2SGB-CDR-0169	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0054 (4788') 2WLC0740 (4788' - 4803') 2TLC0059 (4803') 2RLG0680 (4803') 2SGB-CDR-0170	2SGB-CAB-10 2WLC0737 (4803') 2TLC0066 (4803') 2TLC0067 (4803') 2RLG0684 (4803') 2SGB-FT-0171	2SGB-CAB-10 2WLC0738 (4803') 2TLC0066 (4803') 2TLC0067 (4803') 2RLG0692 (4803') 2SGB-CDR-172	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0055 (4788') 2RLG0676 (4788' - 4803') 2SGB-CDR-173	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0054 (4788') 2RLG0678 (4788' - 4803') 2SGB-CDR-174
Route #	CR19	CR20	CR21	CR22	CR23	CR24
General Desc.	2SGB-CAB-10 to 2SGB-CDR-0175	2SGB-CAB-10 to 2SGB-CDR-0176	2SGB-CAB-9 to 2SGB-CDR-0177	2SGB-CAB-9 to 2SGB-CDR-0178	2SGB-CAB-10 to 2SGB-CDR-179	2SGB-CAB-10 to 2SGB-CDR-180
Detailed Route Desc.	2SGB-CAB-10 2WLC0737 (4803') 2RLG0686 (4803') 2SGB-CDR-0175	2SGB-CAB-10 2WLC0738 (4803') 2RLG0688 (4803') 2SGB-CDR-0176	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0055 (4788') 2RLG0676 (4788' - 4803') 2RLG0677 (4803') 2SGB-CDR-0177	2SGB-CAB-9 2WLC0741 (4788' - 4803') 2TLC0055 (4788') 2RLG0678 (4788' - 4803') 2RLG0679 (4803') 2SGB-CDR-0178	2SGB-CAB-10 2WLC0737 (4803') 2RLG0686 (4803') 2RLG0687 (4803') 2SGB-CDR-179	2SGB-CAB-10 2WLC0738 (4803') 2RLG0688 (4803') 2RLG0689 (4803') 2SGB-CDR-180
Route #	CR25	CR26	CR27	CR28		
General Desc.	2SGB-CAB-11 to 2SGB-TE-1679	2SGB-CAB-12 to 2SGB-TE-1680	2SGB-CAB-13 to 2SGB-TE-1681	2SGB-CAB-14 to 2SGB-TE-1682		
Detailed Route Desc.	2SGB-CAB-11 2RLG0674 (4803') 2SGB-TE-1679	2SGB-CAB-12 2RLG0693 (4803') 2SGB-TE-1680	2SGB-CAB-13 2RLG0694 (4803') 2SGB-TE-1681	2SGB-CAB-14 2RLG0691 (4803') 2SGB-TE-1682		

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

SECTION V - Electrical & Instrument Cable Listing

	Item No.	Type iw=Inst. Wire pw=Pwr.Wire	Description	New Conduit m=multipe circuit s=single circuit		Project Circuit ID	Elev./Column&Row/Routing	Cable Dia.	Route #	**ESTIMATED** Cable Length
	INSTRUMENT WIRING TO CAB									
CCS to South Side Common CAB	1.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-9 4pr/16 awg-FR-shielded/twisted	m		2SGB260901	UCM 13 to 2SGB- CAB-9 - 371'	0.695	CR1	400
	2.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-9 4pr/16 awg-FR-shielded/twisted	m		2SGB260902	UCM 13 to 2SGB- CAB-9 - 371'	0.695	CR1	400
	3.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-9 4pr/16 awg-FR-shielded/twisted	m		2SGB260903	UCM 13 to 2SGB- CAB-9 - 371'	0.695	CR1	400
	4.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-9 4pr/16 awg-FR-shielded/twisted	m		2SGB260904	UCM 13 to 2SGB- CAB-9 - 371'	0.695	CR1	400
	5.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-9 4pr/16 awg-FR-shielded/twisted	m		2SGB260927	UCM 13 to 2SGB- CAB-9 - 371'	0.695	CR1	400
CCS to North Side Common CAB	6.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-10 4pr/16 awg-FR-shielded/twisted	m m m		2SGB261001	UCM 13 to 2SGB- CAB-10 - 487'	0.695	CR2	600
	7.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-10 4pr/16 awg-FR-shielded/twisted	m m m		2SGB261002	UCM 13 to 2SGB- CAB-10 - 487'	0.695	CR2	600
	8.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-10 4pr/16 awg-FR-shielded/twisted	m m m		2SGB261003	UCM 13 to 2SGB- CAB-10 - 487'	0.695	CR2	600
	9.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-10 4pr/16 awg-FR-shielded/twisted	m m m		2SGB261004	UCM 13 to 2SGB- CAB-10 - 487'	0.695	CR2	600
	10.	Iw	3rd lvl relay room to 9th lvl So. side blr center UCM13 to SGB-CAB-10 4pr/16 awg-FR-shielded/twisted	m m m		2SGB261027	UCM 13 to 2SGB- CAB-10 - 487'	0.695	CR2	600
			Total							5000

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

INSTRUMENT WIRING from CABs to FTs, DRVs, & TEs.										
So. Side Common CAB to DRVs	1.	Iw	9th lvl - CAB9 to SW OFA hdr inlet dmpr drive SGB-CAB-9 to CDR-169 1Triad/16 awg-FR-shielded/twisted	m		2SGB260906	2SGB- CAB-9 to 2SGB-CDR-0169- 85'	0.40	CR13	180
	2.	Iw	9th lvl - CAB9 to SE OFA hdr inlet dmpr drive SGB-CAB-9 to CDR-170 1Triad/16 awg-FR-shielded/twisted	m		2SGB260912	2SGB- CAB-9 to 2SGB-CDR-0170- 85'	0.40	CR14	205
	3.	Iw	9th lvl - CAB9 to SW OFA 2/3 port dmpr drive SGB-CAB-9 to CDR-173 1Triad/16 awg-FR-shielded/twisted	m		2SGB260908	2SGB- CAB-9 to 2SGB-CDR-0173- 32'	0.40	CR17	100
	4.	Iw	9th lvl - CAB9 to SE OFA 2/3 port dmpr drive SGB-CAB-9 to CDR-174 1Triad/16 awg-FR-shielded/twisted	m		2SGB260914	2SGB- CAB-9 to 2SGB-CDR-0174- 32'	0.40	CR18	100
	5.	Iw	9th lvl - CAB9 to SW OFA 1/3 port dmpr drive SGB-CAB-9 to CDR-177 1Triad/16 awg-FR-shielded/twisted	m		2SGB260910	2SGB- CAB-9 to 2SGB-CDR-0177- 27'	0.40	CR21	100
	6.	Iw	9th lvl - CAB9 to SE OFA 1/3 port dmpr drive SGB-CAB-9 to CDR-178 1Triad/16 awg-FR-shielded/twisted	m		2SGB260916	2SGB- CAB-9 to 2SGB-CDR-0178- 27'	0.40	CR22	100
No. Side Common CAB to DRVs	7.	Iw	9th lvl - CAB10 to NW OFA hdr inlet dmpr drive SGB-CAB-10 to CDR-171 1Triad/16 awg-FR-shielded/twisted	m		2SGB261006	2SGB- CAB-10 to 2SGB-CDR-0171- 85'	0.40	CR15	215
	8.	Iw	9th lvl - CAB10 to NE OFA hdr inlet dmpr drive SGB-CAB-10 to CDR-172 1Triad/16 awg-FR-shielded/twisted	m		2SGB261012	2SGB- CAB-10 to 2SGB-CDR-0172- 85'	0.40	CR16	215
	9.	Iw	9th lvl - CAB10 to NW OFA 2/3 port dmpr drive SGB-CAB-10 to CDR-175 1Triad/16 awg-FR-shielded/twisted	m		2SGB261008	2SGB- CAB-10 to 2SGB-CDR-0175- 32'	0.40	CR19	85
	10.	Iw	9th lvl - CAB10 to NE OFA 2/3 port dmpr drive SGB-CAB-10 to CDR-176 1Triad/16 awg-FR-shielded/twisted	m		2SGB261014	2SGB- CAB-10 to 2SGB-CDR-0176- 32'	0.40	CR20	85

	11.	Iw	9th lvl - CAB10 to NW OFA1/3 port dmpr driveSGB-CAB-10 to CDR-179 1Triad/16 awg-FR-shielded/twisted	m		2SGB261010	2SGB- CAB-10 to 2SGB-CDR-0179- 27'	0.40	CR23	85
	12.	Iw	9th lvl - CAB10 to NE OFA 1/3 port dmpr drive SGB-CAB-10 to CDR-180 1Triad r/16 awg-FR-shielded/twisted	m		2SGB261016	2SGB- CAB-10 to 2SGB-CDR-0180- 27'	0.40	CR24	85
			Total							1555
Common CAB to CAMS panels	13.	Iw	9th lvl CAB9 to SW OFA CAMS flw xmiter 2SGB-CAB-9 to 2SGB-CAB-0011 1pr/16 awg-FR-shielded/twisted			2SGB260925	2SGB- CAB-9 to 2SGB-CAB-0011- 80'	0.37	CR9	140
	14.	Iw	9th lvl CAB 9 to SE OFA CAMS flw xmiter 2SGB-CAB-9 to 2SGB-CAB-0012 1pr/16 awg-FR-shielded/twisted			2SGB260926	2SGB- CAB-9 to 2SGB-CAB-0012- 80'	0.37	CR10	170
	15.	Iw	9th lvl CAB10 to NW OFA CAMS flw xmiter 2SGB-CAB-10 to 2SGB-CAB-0013 1pr/16 awg-FR-shielded/twisted			2SGB261025	2SGB- CAB-10 to 2SGB-CAB-0013- 80'	0.37	CR11	175
	16.	Iw	9th lvl CAB10 to NE OFA CAMS flw xmiter 2SGB-CAB-10 to 2SGB-CAB-0014 1pr/16 awg-FR-shielded/twisted			2SGB261026	2SGB- CAB-10 to 2SGB-CAB-0014- 80'	0.37	CR12	175
CCS A1-A4 to A3 Sect 9	17.	Iw	3rd lvl CCS A3 to CCS A3,Sect9 2COA-CAB-A3 to 2COA-CAB-A3, sect 9 1pr/16 awg-FR-shielded/twisted				From CCS Cab A3 to A3, sect9 via wiring galley	0.37		70
	18.	Iw	3rd lvl CCS A3 to CCS A3,Sect9 2COA-CAB-A3 to 2COA-CAB-A3, sect 9 1pr/16 awg-FR-shielded/twisted				From CCS Cab A3 to A3, sect9 via wiring galley	0.37		70
	19.	Iw	3rd lvl CCS A4 to CCS A3,Sect9 2COA-CAB-A4 to 2COA-CAB-A3, sect 9 1pr/16 awg-FR-shielded/twisted				From CCS Cab A4 to A3, sect9 via wiring galley	0.37		80
	20.	Iw	3rd lvl CCS A4 to CCS A3,Sect9 2COA-CAB-A4 to 2COA-CAB-A3, sect 9 1pr/16 awg-FR-shielded/twisted				From CCS Cab A4 to A3, sect9 via wiring galley	0.37		80
	21.	Iw	3rd lvl CCS A1 to CCS A3,Sect9 2COA-CAB-A1 to 2COA-CAB-A3, sect 9 1pr/16 awg-FR-shielded/twisted				From CCS Cab A1 to A3, sect9 via wiring galley	0.37		75
	22.	Iw	3rd lvl CCS A2 to CCS A3,Sect9 2COA-CAB-A2 to 2COA-CAB-A3, sect 9 1pr/16 awg-FR-shielded/twisted				From CCS Cab A2 to A3, sect9 via wiring galley	0.37		110
			Total							1145

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

SW CAMS CAB to TEs	1.	Iw	9th lvl CAB11to SW OFA Duct TE SGB-CAB-11 to TE-1679 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261102	2SGB- CAB-9 to 2SGB-TE-1679- 50'	0.25	CR25	50
	2.	Iw	9th lvl CAB11to SW OFA Duct TE SGB-CAB-11 to TE-1679 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261109	2SGB- CAB-9 to 2SGB-TE-1679- 50'	0.25	CR25	50
	3.	Iw	9th lvl CAB11to SW OFA Duct TE SGB-CAB-11 to TE-1679 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261110	2SGB- CAB-9 to 2SGB-TE-1679- 50'	0.25	CR25	50
SE CAMS CAB to TEs	4.	Iw	9th lvl CAB 9 to SE OFA CAMS flw xmiter SGB-CAB-11 to TE-1680 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261104	2SGB- CAB-9 to 2SGB-TE-1680- 50'	0.25	CR26	50
	5.	Iw	9th lvl CAB 9 to SE OFA CAMS flw xmiter SGB-CAB-11 to TE-1680 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261111	2SGB- CAB-9 to 2SGB-TE-1680- 50'	0.25	CR26	50
	6.	Iw	9th lvl CAB 9 to SE OFA CAMS flw xmiter SGB-CAB-11 to TE-1680 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261112	2SGB- CAB-9 to 2SGB-TE-1680- 50'	0.25	CR26	50
NW CAMS CAB to TEs	7.	Iw	9th lvl CAB10 to NW OFA CAMS flw xmiter SGB-CAB-11 to TE-1681 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261106	2SGB- CAB-10 to 2SGB-TE-1681-50'	0.25	CR27	50
	8.	Iw	9th lvl CAB10 to NW OFA CAMS flw xmiter SGB-CAB-11 to TE-1681 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261113	2SGB- CAB-10 to 2SGB-TE-1681- 50'	0.25	CR27	50
	9.	Iw	9th lvl CAB10 to NW OFA CAMS flw xmiter SGB-CAB-11 to TE-1681 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261114	2SGB- CAB-10 to 2SGB-TE-1681- 50'	0.25	CR27	50
NE CAMS CAB to TEs	10.	Iw	9th lvl CAB10 to NE OFA CAMS flw xmiter SGB-CAB-11 to TE-1682 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261108	2SGB- CAB-10 to 2SGB-TE-1682- 50'	0.25	CR28	50
	11.	Iw	9th lvl CAB10 to NE OFA CAMS flw xmiter SGB-CAB-11 to TE-1682 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261115	2SGB- CAB-10 to 2SGB-TE-1682- 50'	0.25	CR28	50
	12.	Iw	9th lvl CAB10 to NE OFA CAMS flw xmiter SGB-CAB-11 to TE-1682 **1pr.**16 awg-T/C ext cable, lengths of **50' ea.**	m		2SGB261116	2SGB- CAB-10 to 2SGB-TE-1682- 50'	0.25	CR28	50
			Total							600
POWER										

IP7_036899

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

PPL to South COMMON CAB	1.	Pw	8th lvl SE to 9th lvl south center PPL-009 to 2SGB-CAB-9, CDR169, 12 awg-FR-3/C			2SGB260917	PPL009 (4788' 11") to CAB-9 - 75' - Route 4	0.5	CR4	100
	2.	Pw	8th lvl SE to 9th lvl south center PPL-009 to 2SGB-CAB-9, CDR170, 12 awg-FR-3/C			2SGB260920	PPL009 (4788' 11") to CAB-9 - 75' - Route 4	0.5	CR4	100
	3.	Pw	8th lvl SE to 9th lvl south center PPL-009 to 2SGB-CAB-9, CDR173, 12 awg-FR-3/C			2SGB260918	PPL009 (4788' 11") to CAB-9 - 75' - Route 4	0.5	CR4	100
	4.	Pw	8th lvl SE to 9th lvl south center PPL-009 to 2SGB-CAB-9, CDR175, 12 awg-FR-3/C			2SGB260921	PPL009 (4788' 11") to CAB-9 - 75' - Route 4	0.5	CR4	100
	5.	Pw	8th lvl SE to 9th lvl south center PPL-009 to 2SGB-CAB-9, CDR177. 12 awg-FR-3/C			2SGB260919	PPL009 (4788' 11") to CAB-9 - 75' - Route 4	0.5	CR4	100
	6.	Pw	8th lvl SE to 9th lvl south center PPL-009 to 2SGB-CAB-9, CDR178, 12 awg-FR-3/C			2SGB260922	PPL009 (4788' 11") to CAB-9 - 75' - Route 4	0.5	CR4	100
PPLs to CAMS	7.	Pw	8th lvl SW to 9th lvl SW PPL-008 to 2SGB-CAB-11, 12 awg-FR-3/C			2SGB260923	PPL008 (4788' 11") to 2SGB-CAB-11	0.5	CR5	115
	8.	Pw	8th lvl SE to 9th lvl SE PPL-009 to 2SGB-CAB-12, 12 awg-FR-3/C			2SGB260924	PPL008 (4788' 11") to 2SGB-CAB-12	0.5	CR7	140
	9.	Pw	8th lvl SW to 9th lvl NW PPL-008 to 2SGB-CAB-13, 12 awg-FR-3/C			2SGB261023	PPL008 (4788' 11") to 2SGB-CAB-13	0.5	CR6	265
	10.	Pw	8th lvl SE to 9th lvl NE PPL-009 to 2SGB-CAB-14, 12 awg-FR-3/C			2SGB261024	PPL009 (4788' 11") to 2SGB-CAB14	0.5	CR8	275
PPL to North COMMON CAB	11.	Pw	8th lvl SE to 9th lvl north center PPL-008 to 2SGB-CAB-10, CDR171, 12 awg-FR-3/C			2SGB261017	PPL008 (4788' 11") to CAB-10 - 310' - Route 3	0.5	CR3	400
	12.	Pw	8th lvl SE to 9th lvl north center PPL-008 to 2SGB-CAB-10, CDR172, 12 awg-FR-3/C			2SGB261020	PPL008 (4788' 11") to CAB-10 - 310' - Route 3	0.5	CR3	400
	13.	Pw	8th lvl SE to 9th lvl north center PPL-008 to 2SGB-CAB-10, CDR175, 12 awg-FR-3/C			2SGB260918	PPL008 (4788' 11") to CAB-10 - 310' - Route 3	0.5	CR3	400
	14.	Pw	8th lvl SE to 9th lvl north center PPL-008 to 2SGB-CAB-10, CDR176,12 awg-FR-3/C			2SGB260921	PPL008 (4788' 11") to CAB-10 - 310' - Route 3	0.5	CR3	400

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

	15.	Pw	8th lvl SE to 9th lvl north center PPL-008 to 2SGB-CAB-10, CDR179. 12 awg-FR-3/C	m m		2SGB260919	PPL008 (4788' 11") to CAB-10 - 310' - Route 3	0.5	CR3	400
	16.	Pw	8th lvl SE to 9th lvl north center PPL-008 to 2SGB-CAB-10, CDR180, 12 awg-FR-3/C	m m		2SGB260922	PPL008 (4788' 11") to CAB-10 - 310' - Route 3	0.5	CR3	400
							Total			3795
So. side Common CAB to DRVs	17.	Pw	9th lvl CAB to SW OFA inlet dmpr drive 2SGB-CAB-9 to CDR-169, 12 awg-FR-4/C	m		2SGB260905	2SGB- SGB-CAB-9 to 2SGB-CDR-0169- 85'	0.54	CR13	180
	18.	Pw	9th lvl CAB to SE OFA inlet dmpr drive SGB-CAB-9 to CDR-170, 12 awg-FR-4/C	m		2SGB260911	2SGB- CAB-9 to 2SGB-CDR-0170- 85'	0.54	CR14	205
	19.	Pw	9th lvl CAB to SW OFA 2/3 port dmpr drive SGB-CAB-9 to CDR-173, 12 awg-FR-4/C	m		2SGB260907	2SGB- CAB-9 to 2SGB-CDR-0173- 32'	0.54	CR17	100
	20.	Pw	9th lvl CAB to SE OFA 2/3 port dmpr drive SGB-CAB-9 to CDR-174, 12 awg-FR-4/C	m		2SGB260913	2SGB- CAB-9 to 2SGB-CDR-0174- 32'	0.54	CR18	100
	21.	Pw	9th lvl CAB to SW OFA 1/3 port dmpr drive SGB-CAB-9 to CDR-177, 12 awg-FR-4/C	m		2SGB260909	2SGB- CAB-9 to 2SGB-CDR-0177- 27'	0.54	CR21	100
	22.	Pw	9th lvl CAB to SE OFA 1/3 port dmpr drive SGB-CAB-9 to CDR-178, 12 awg-FR-4/C /C	m		2SGB260915	2SGB- CAB-9 to 2SGB-CDR-0178- 27'	0.54	CR22	100
North side CAB to DRVs	23.	Pw	9th lvl CAB to NW OFA inlet dmpr drive SGB-CAB-10 to CDR-171, 12 awg-FR-4/C	m m		2SGB261005	2SGB- CAB-10 to 2SGB-CDR-0171- 85'	0.54	CR15	215
	24.	Pw	9th lvl CAB to NE OFA inlet dmpr drive SGB-CAB-10 to CDR-172, 12 awg-FR-4/C	m m		2SGB261011	2SGB- CAB-10 to 2SGB-CDR-0172- 85'	0.54	CR16	215
	25.	Pw	9th lvl CAB to NW OFA 2/3 port dmpr drive SGB-CAB-10 to CDR-175, 12 awg-FR-4/C	m m		2SGB261007	2SGB- CAB-10 to 2SGB-CDR-0175- 32'	0.54	CR19	85
	26.	Pw	9th lvl CAB to NE OFA 2/3 port dmpr drive SGB-CAB-10 to CDR-176, 12 awg-FR-4/C	m m		2SGB261013	2SGB- CAB-10 to 2SGB-CDR-0176- 32'	0.54	CR20	85
	27.	Pw	9th lvl CAB to NW OFA1/3 port dmpr drive SGB-CAB-10 to CDR-179, 12 awg-FR-4/C	m m		2SGB261009	2SGB- CAB-10 to 2SGB-CDR-0179- 27'	0.54	CR23	85
	28.	Pw	9th lvl CAB to NE OFA 1/3 port dmpr drive SGB-CAB-10 to CDR-180, 12 awg-FR-4/C	m m		2SGB261015	2SGB- CAB-10 to 2SGB-CDR-0180- 27'	0.54	CR24	85
			Total							1555

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

SECTION VI - NEW CONDUIT & Included Cables

Conduit	Routes	Included Cables	Dia. Cable	Area/Cable	Total Cable Area	Minimum Recommended Conduit Size
2WLC0737	CR3	2SGBK261017 2SGBK261018 2SGBK261019 2SGBK261020 2SGBK261021 2SGBK261022	.5 .5 .5 .5 .5 .5	.2 .2 .2 .2 .2 .2	2.39	8" X 8" Wireway
	CR11	2SGBK261025	.37	.11		
	CR15	2SGBK261005 2SGBK261006	.54 .4	.23 .13		
	CR19	2SGBK261007 2SGBK261008	.54 .4	.23 .13		
	CR23	2SGBK261009 2SGBK261010	.54 .4	.23 .13		
2WLC0738	CR2	2SGBK261001 2SGBK261002 2SGBK261003 2SGBK261004 2SGBK261027	.695 .695 .695 .695 .695	.38 .38 .38 .38 .38	3.09	8" X 8" Wireway
	CR12	2SGBK251025	.37	.11		
	CR16	2SGBK261011 2SGBK261012	.54 .4	.23 .13		
	CR20	2SGBK261013 2SGBK261014	.54 .4	.23 .13		
	CR24	2SGBK261015 2SGBK261016	.54 .4	.23 .13		
2WLC0739	CR3	2SGBK261017 2SGBK261018 2SGBK261019 2SGBK261020 2SGBK261021 2SGBK261022	.5 .5 .5 .5 .5 .5	.2 .2 .2 .2 .2 .2	2.07	8" X 8" Wireway
	CR5	2SGBK261023	.5	.2		
	CR6	2SGBK261024	.5	.2		
	CR9	2SGBK260925	.37	.11		

	CR13	2SGBK260905 2SGBK260906	.54 .4	.23 .13		
2WLC0740	CR2	2SGBK261001 2SGBK261002 2SGBK261003 2SGBK261004 2SGBK261027	.695 .695 .695 .695 .695	.38 .38 .38 .38 .38	2.77	8" X 8" Wireway
	CR7	2SGBK260923	.5	.2		
	CR8	2SGBK260924	.5	.2		
	CR10	2SGBK260926	.37	0.11		
	CR14	2SGBK260911 2SGBK260912	.54 .4	.23 .13		
2WLC0741	CR1	2SGBK260901 2SGBK260902 2SGBK260903 2SGBK260904 2SGBK260927	.695 .695 .695 .695 .695	.38 .38 .38 .38 .38	5.77	8" X 8" Wireway
	CR4	2SGBK260917 2SGBK260918 2SGBK260919 2SGBK260920 2SGBK260921 2SGBK260922	.5 .5 .5 .5 .5 .5	.2 .2 .2 .2 .2 .2		
	CR5	2SGBK261023	.5	0.2		
	CR6	2SGBK261024	.5	0.2		
	CR9	2SGBK260925	.37	.11		
	CR13	2SGBK260905 2SGBK260906	.54 .4	.23 .13		
	CR14	2SGBK260911 2SGBK260912	.54 .4	.23 .13		
	CR17	2SGBK260907 2SGBK260908	.54 .4	.23 .13		
	CR18	2SGBK260913 2SGBK260914	.54 .4	.23 .13		
	CR21	2SGBK260909 2SGBK260910	.54 .4	.23 .13		
	CR22	2SGBK260915 2SGBK260916	.54 .4	.23 .13		

2RLG0672	CR5	2SGBK261023	.5	.2	0.5724	1.5
	CR9	2SGBK260925	.37	.11		
		Grounding cable	.578	.2624		
2RLG0673	CR13	2SGBK260905 2SGBK260906	.54 .4	.23 .13	0.36	1.5
2RLG0674	CR25	2SGBK261102 2SGBK261109 2SGBK261110	.25 .25 .25	.1 .1 .1	0.3	1
2RLG0676	CR17	2SGBK260907 2SGBK260908	.54 .4	.23 .13	0.72	2
	CR21	2SGBK260909 2SGBK260910	.54 .4	.23 .13		
2RLG0677	CR21	2SGBK260909 2SGBK260910	.54 .4	.23 .13	0.36	1.5
2RLG0678	CR18	2SGBK260913 2SGBK260914	.54 .4	.23 .13	0.72	2
	CR22	2SGBK260915 2SGBK260916	.54 .4	.23 .13		
2RLG0679	CR22	2SGBK260915 2SGBK260916	.54 .4	.23 .13	0.36	1.5
2RLG0680	CR14	2SGBK260911 2SGBK260912	.54 .4	.23 .13	0.36	1.5
2RLG0681	CR7	2SGBK260923	.5	.2	0.5724	1.5
	CR10	2SGBK260926	.37	.11		
		Grounding cable	.578	.2624		
2RLG0682	CR3	2SGBK261017 2SGBK261018 2SGBK261019 2SGBK261020 2SGBK261021 2SGBK261022	.5 .5 .5 .5 .5 .5	.2 .2 .2 .2 .2 .2	1.6	3
	CR5	2SGBK261023	.5	0.2		
	CR6	2SGBK261024	.5	0.2		

IP7_036904

OVERFIRE AIR (OFA) PROJECT - IGS02-14 - Electrical cable and conduit Installation

2RLG0683	CR4	2SGBK260917 2SGBK260918 2SGBK260919 2SGBK260920 2SGBK260921 2SGBK260922	.5 .5 .5 .5 .5 .5	.2 .2 .2 .2 .2 .2	1.6	3
	CR7	2SGBK260923	.5	.2		
	CR8	2SGBK260924	.5	.2		
2RLG0684	CR15	2SGBK261005 2SGBK261006	.54 .4	.23 .13	0.36	1.5
2RLG0685	CR6	2SGBK261024	.5	0.2	0.5724	1.5
	CR11	2SGBK261025	.37	.11		
		Grounding cable	.578	.2624		
2RLG0686	CR19	2SGBK261007 2SGBK261008	.54 .4	.23 .13	0.72	2
	CR23	2SGBK261009 2SGBK261010	.54 .4	.23 .13		
2RLG0687	CR23	2SGBK261009 2SGBK261010	.54 .4	.23 .13	0.36	1.5
2RLG0688	CR20	2SGBK261013 2SGBK261014	.54 .4	.23 .13	0.72	2
	CR24	2SGBK261015 2SGBK261016	.54 .4	.23 .13		
2RLG0689	CR24	2SGBK261015 2SGBK261016	.54 .4	.23 .13	0.36	1.5
2RLG0690	CR8	2SGBK260924	.5	.2	0.5724	1.5
	CR12	2SGBK251025	.37	.11		
		Grounding cable	.578	.2624		
2RLG0691	CR28	2SGBK261104 2SGBK261111 2SGBK261112	.25 .25 .25	.1 .1 .1	0.3	1
2RLG0692	CR16	2SGBK261011 2SGBK261012	.54 .4	.23 .13	0.36	1.5

2RLG0693	CR26	2SGBK261106 2SGBK261113 2SGBK261114	.25 .25 .25	.1 .1 .1	0.3	1
2RLG0694	CR27	2SGBK261108 2SGBK261115 2SGBK261116	.25 .25 .25	.1 .1 .1	0.3	1

Unit 2 - Over Fire Air Equipment - Tagging List							
Item	Description	Project ID	Elev./ Column & Row	Model, Size, or Diameter	Breaker Location/ Power Source	Normal Position	De-energized position
1.	SW OFA Header Inlet Dmpr Drive	2SGB-CDR-0169	4803'	Jordan 5220	2APA-PPL-009 BRKR 24	Closed	Open
2.	SE OFA Header Inlet Dmpr Drive	2SGB-CDR-0170	4803'	Jordan 5220	2APA-PPL-009 BRKR 30	Closed	Open
3.	NW OFA Header Inlet Dmpr Drive	2SGB-CDR-0171	4803'	Jordan 5220	2APA-PPL-008 BRKR 17	Closed	Open
4.	NE OFA Header Inlet Dmpr Drive	2SGB-CDR-0172	4803'	Jordan 5220	2APA-PPL-008 BRKR 27	Closed	Open
5.	SW OFA 2/3 Dmpr Drive	2SGB-CDR-0173	4803'	Jordan 5220	2APA-PPL-009 BRKR 26	Closed	Open
6.	SE OFA 2/3 Dmpr Drive	2SGB-CDR-0174	4803'	Jordan 5220	2APA-PPL-009 BRKR 32	Closed	Open
7.	NW OFA 2/3 Dmpr Drive	2SGB-CDR-0175	4803'	Jordan 5220	2APA-PPL-008 BRKR 19	Closed	Open
8.	NE OFA 2/3 Dmpr Drive	2SGB-CDR-0176	4803'	Jordan 5220	2APA-PPL-008 BRKR 29	Closed	Open
9.	SW OFA 1/3 Dmpr Drive	2SGB-CDR-0177	4803'	Jordan 5220	2APA-PPL-009 BRKR 28	Closed	Open
10.	SE OFA 1/3 Dmpr Drive	2SGB-CDR-0178	4803'	Jordan 5220	2APA-PPL-009 BRKR 34	Closed	Open
11.	NW OFA 1/3 Dmpr Drive	2SGB-CDR-0179	4803'	Jordan 5220	2APA-PPL-008 BRKR 25	Closed	Open
12.	NE OFA 1/3 Dmpr Drive	2SGB-CDR-0180	4803'	Jordan 5220	2APA-PPL-008 BRKR 31	Closed	Open
13.	OFA Hdr SW Inlet Flow CAMS CAB	2SGB-CAB-0011	4803'	Air Monitor CAMS	2APA-PPL-008 BRKR 33	Closed	Open
14.	OFA Hdr SE Inlet Flow CAMS CAB	2SGB-CAB-0012	4803'	Air Monitor CAMS	2APA-PPL-009 BRKR 36	Closed	Open
15.	OFA Hdr NW Inlet Flow CAMS CAB	2SGB-CAB-0013	4803'	Air Monitor CAMS	2APA-PPL-008 BRKR 35	Closed	Open
16.	OFA Hdr NE Inlet Flow CAMS CAB	2SGB-CAB-0014	4803'	Air Monitor CAMS	2APA-PPL-009 BRKR 38	Closed	Open

* Need clearance on PPL-008 and PPL-009 listed above, or OK_To, to connect wiring.

** Following wiring connection, need clearance or OK_To on breakers to allow for connection to amplifiers and drives.

ADDENDUM TO 1APA-PPL-009 (IGS02-14)
16 - OFA SW INLET DMPR DRV - 1SGB-CDR-169
18 - OFA SW 2/3 PORT DMPR DRV - 1SGB-CDR-173
20 - OFA SW 1/3 PORT DMPR DRV - 1SGB-CDR-177
22 - SEE ABOVE.
24 - OFA SE INLET DMPR DRV - 1SGB-CDR-170
26 - OFA SE 2/3 PORT DMPR DRV - 1SGB-CDR-174
28 - OFA SE 1/3 PORT DMPR DRV - 1SGB-CDR-178
30 - OFA SE CAMS SYSTEM CABINET - 1SGB-CAB-12
32 - OFA NE CAMS SYSTEM CABINET - 1SGB-CAB-14

ADDENDUM TO 1APA-PPL-008 (IGS02-14)
25 - OFA NW INLET DMPR DRV - 1SGB-CDR-171
27 - OFA NW 2/3 PORT DMPR DRV - 1SGB-CDR-175
29 - OFA NW 1/3 PORT DMPR DRV - 1SGB-CDR-179
31 - OFA NE INLET DMPR DRV - 1SGB-CDR-172
33 - OFA NE 2/3 PORT DMPR DRV - 1SGB-CDR-176
35 - OFA NE 1/3 PORT DMPR DRV - 1SGB-CDR-180
37 - OFA SW CAMS SYSTEM CABINET - 1SGB-CAB-11
39 - OFA NW CAMS SYSTEM CABINET - 1SGB-CAB-13

Jordan CONTROLS

IM-0422

SM-5100 Series Rotary Actuator

Table of Contents

Failure to properly wire torque/thrust switches will result in actuator damage.

Refer to the specific wiring diagram supplied with your actuator for correct wiring.

Due to wide variations in the terminal numbering of actuator products, actual wiring of this device should follow the print supplied with the unit.

GENERAL INFORMATION

INTRODUCTION

Jordan Controls, Inc., designs, manufactures, and tests its products to meet national and international standards. For these products to operate within their normal specifications, they must be properly installed and maintained. The following instructions must be followed and integrated with your safety program when installing, using, and maintaining Jordan Controls products:

Read and save all instructions prior to installing, operating, and servicing this product.

If any of the instructions are not understood, contact your Jordan Controls representative for clarification.

Follow all warnings, cautions, and instructions marked on, and supplied with, the product.

Inform and educate personnel in the proper installation, operation, and maintenance of the product.

Install equipment as specified in Jordan Controls installation instructions and per applicable local and national codes. Connect all products to the proper electrical sources.

To ensure proper performance, use qualified personnel to install, operate, update, tune, and maintain the product.

When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Jordan Controls. Substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.

Keep all actuator protective covers in place (except when installing, or when maintenance is being performed by qualified personnel), to prevent electrical shock, personal injury, or damage to the actuator.

⚠ WARNING

Before installing the actuator, make sure that it is suitable for the intended application. If you are unsure of the suitability of this equipment for your installation, consult Jordan Controls prior to proceeding.

⚠ WARNING - SHOCK HAZARD

Installation and servicing must be performed only by qualified personnel.

⚠ WARNING - ELECTROSTATIC DISCHARGE

This electronic control is static-sensitive. To protect the internal components from damage caused by static discharge, never touch the printed circuit cards without being statically protected.

RECEIVING INSPECTION

Carefully inspect for shipping damage. Damage to the shipping carton is usually a good indication that it has received rough handling. Report all damage immediately to the freight carrier and Jordan Controls, Inc.

Verify that the items on the packing list or bill of lading agree with your own.

STORAGE

If the actuator will not be installed immediately, it should be stored indoors in a clean, dry area where the ambient temperature is not less than -20° F. The actuator should be stored in a non-corrosive environment. The actuator is not sealed to NEMA 4 until the conduit entries are properly connected.

EQUIPMENT RETURN

A Returned Goods authorization (RG) number is required to return any equipment for repair. This must be obtained from Jordan Controls. (Telephone: 414/461-9200) The equipment must be shipped, freight prepaid, to the following address after the RG number is issued:

Jordan Controls, Inc.
5607 West Douglas Avenue
Milwaukee, Wisconsin 53218
Attn: Service Department

To facilitate quick return and handling of your equipment, include:

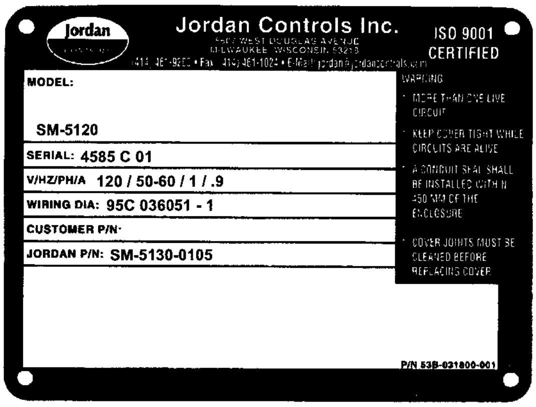
- RG Number on outside of box
- Your Company Name, Contact Person, Phone/Fax # Address
- Repair Purchase Order Number
- Brief description of the problem

GENERAL INFORMATION

IDENTIFICATION LABEL

An identification label is attached to each actuator cover. The serial number is also stamped on the aluminum housing, directly above the conduit entry. When ordering parts, requesting information or service assistance, please provide all of the label information.

EXAMPLE:



MODEL NUMBER: **SM-5130 Series**

SERIAL NUMBER: **4585 C 01**

Sequential Number — 4585

Month Built — C

Year Built — 01

GENERAL DESCRIPTION, ACTUATOR

The SM-5000 Series are quarter turn, rotary actuators that produce up to 12,500 ft. lbs. (16,947 Nm) of torque, and offer continuous modulating duty up to 4,000 starts per hour. They are designed for up to 90° rotation with bi-directional torque overload protection and have a manual override handcrank. This series of actuators uses a scotch-yoke output gearing design that provides up to 66% more torque at the ends of travel (0° and 90° positions). The SM-5000 Series is ideally suited for dampers, vanes and valve control requiring high torque and exact position control.

All SM-5000 Series actuators are also available with an internal amplifier (excluding SM-5140). These amplifiers are all full-featured ac or dc switching devices designed to seamlessly work with the actuator for closed loop control.

The SM-5100 series includes 120/240 Vac single phase models, 208/240/380/480 Vac three phase models, and 24 and 90 Vdc models. Up to six independently adjustable position limit switches are available as options.

ABBREVIATIONS USED IN THIS MANUAL

A	Ampere
AC	Alternating Current
° C	Degrees Celsius
CW	Clockwise
CCW	Counterclockwise
DC	Direct Current
° F	Degrees Fahrenheit
G	Earth Ground
Hz	Hertz
in. lbs.	Inch Pounds
kg	Kilogram
L	Line (power supply)
lbs.	Pounds Force
LVDT	Linear Variable Differential Transformer
mA	Milliamp
mfd	Microfarad
mm	Millimeters
N	Newton (force)
NEMA	National Electrical Manufacturing Association
Nm	Newton Meter
NPT	National Pipe Thread
PH	Phase
PL	Position Limit Switch
RPM	Revolutions per Minute
SEC	Second
TL	Torque Limit Switch
V	Volts
VA	Volt Amps
Vac	Volts ac
Vdc	Volts dc
VR	Variable Resistance
W	Watt

BASIC MODELS

The **SM-5120** and **SM-5190** are single phase ac, three wire, plug reversible models.

These models may also be equipped with an internal AD-8130 servo amplifier that features loss of signal detection for current command signal inputs and can be calibrated to allow the actuator to lock-in-place or drive to a preset position should the command signal drop below 3.8mA. Also included is a dynamic brake circuit to increase positioning accuracy and a loop-powered, 4 to 20mA position transmitter.

The **SM-5115** is a three phase ac, reversible model, and can be equipped with an internal AD-8900 series servo amplifier.

The **SM-5140** and **SM-5160** are dc proportional control models. These actuators may be equipped with an internal AD-7830 or AD-9120 servo amplifier, or external AD-7830, AD-9120 or AD-7540 servo amplifier.

SM-5100 Series Specifications

Rotation: Up to 90°

Duty Cycle: AC: 2,000 1% position changes/hour.
DC: 4,000 1% position changes/hour.

Temperature: -40°F to 150°F (-40°C to 65°C).

Environment Ratings: NEMA Type 4 (IP65) or Explosion Proof, Class I, Division 1, Groups C& D. Class II, Division 1, Groups E, F & G.

Weight: Approximately 80 lbs. (36 kg).

Enclosure Materials: Cast aluminum alloy.

Lubrication Type: Grease, permanently lubricated.

Gearing: Spur type.

Hold on Loss of Power: Self-locking. Optional brake allows improved positioning response.

Mounting: Any position.

Torque Limiting: Bi-Directional, disables motor in one direction when torque rating is exceeded.

Output Shaft: One inch (25.4mm) diameter with 20 tooth spline, or one inch (25.4mm) diameter with 0.25 inch square (6.35 mm) keyway.

Anti-Condensation Heater: 120 or 240 Vac, 30 Watt with thermostat set for 110°F (43.3°C).

Position Feedback: 1000 ohm potentiometer. Optional contactless feedback available.

Field Wiring: To barrier type terminal blocks.

Integral Thermal Protection/Single Phase AC Motor: Standard thermal overload protection at 130°C, self resetting.

End-of-Travel Position Limit Switches:
20 amp, 250 Vac

Actuator Model	Input Power Volts/Phase/Hz	Current (Amps)		Amplifier Model		*Time/Torque sec./ft. lbs. (Nm)
		Run	Stall	Inernal	Remote	
SM-5115	240/3/50-60	0.4	1.3	AD-8900	AD-8900	16/150 (203) 29/300 (407) 48/300 (407)
	380/3/50	0.3	0.9			
	480/3/50-60	0.2	0.65			
SM-5120	120/1/50-60	2.5	2.9	AD-8130	AD-8230	16/150 (203) 29/300 (407) 48/300 (407)
SM-5140	24 Vdc	4.5	10	NA	AD-7540	20/150 (203) 33/300 (407)
SM-5160	90 Vdc	2.5	6	NA	AD-7830 or AD-9120	13/150 (203) 24/300 (407) 39/300 (407)
	120/1/50-60			AD-7830 or AD-9120	NA	
	208/1/50-60					
	240/1/50-60					
SM-5190	240/1/50-60	1.2	1.5	AD-8130	AD-8230	16/150 (203) 29/300 (407) 48/300 (407)

**Multiply these shift times by 1.2 for 50 Hz operation of AC models. All travel times are nominal for 90° of movement.*

OPTION SPECIFICATIONS

Servo Amplifiers: All servo amplifiers include a field-adjustable command signal monitor that can be set for lock-in-place, or drive to a pre-set position if the current command signal is lost. They also have a dynamic brake circuit which helps increase positioning accuracy of the loop by minimizing motor coast. These amplifiers are also equipped with a 4-20mA isolated two wire, loop-powered transmitter.

Local Auto/Manual, INC/OFF/DEC Toggle Switches: Actuator-mounted switches for control of Auto/Manual and INCREASE/OFF/DECREASE. These are available as toggle switches or NEMA style rotary switches.

Output Shaft: One inch (25.4mm) diameter with 0.25 inch square (6.35 mm) keyway.

20 Tooth Splined Drive Arm: Reversible for ½ tooth positioning.

Linkage Kit: Includes two clevises, two adjustment rods with lock nuts, two pipe adapters, two pins for clevises.

Auxiliary Position Limit Switches: (two or four): 20 amps, 250 Vac maximum, or 5 amps at 28 Vdc.

Transmitter Position Feedback: 4 to 20mA, isolated two wire loop-powered type. Tracks actuator position. Requires separate power.

Local Position Indicator: Reversible indicator to show open or close in either direction.

Local Control: Actuator mounted NEMA 4 rated switches for control of AUTO/MANUAL and INCREASE/OFF/DECREASE. These are available as toggle switches or NEMA-style rotary switches.

LVDT Contactless Feedback: Characterized feedback assembly directly replaces the standard linear feedback potentiometer.

Installation

MOUNTING

The outline and mounting dimensions for a standard unit are shown on page 23 of this manual. The rear cover opposite output shaft must have clearance so that it may be removed for adjustments and interconnect wiring. When the actuator is directly coupled to a drive shaft, it is recommended that a flexible, no backlash type coupling be used. The output shaft is also available with a splined output for standard lever arms and linkage drive to the driven load. The unit may be mounted on the standard foot mount, or a flange mount. Mounting may be in any position convenient to the driven load.

When mounting the unit, be sure that no excessive axial or side loading is applied to the output shaft. The limit switches and position feedback are connected through gearing to the output shaft of the actuator which should be positively secured to the driven load shaft so that no slippage can occur which would cause misalignment or damage.

When manual override is required, as in the event of a power failure, turn the crank in the proper direction for the desired output shaft rotation. If during manual operation, electric power is applied to the actuator, the selector lever will return to the "auto" position and the actuator will respond to the power command, The shift from "manual" to "auto" disengages the manual crank, which cannot be power driven, thereby protecting the operator.

Care, however, should be taken when driving a load to recognize that excessive output torque may be developed

by forcing the handcrank. A mechanical telltail-indicator shaft adjacent to the crank indicates over-torquing. The telltail-indicator shaft will either protrude or recede depending on the direction of over-torquing. Discontinue cranking on over-torque warning.

The motor, limit switch and feedback area of the actuator depends upon the cover to maintain the NEMA 4 rating. This cover should be removed only when actual work is being done in that area and reinstalled immediately thereafter.

This actuator contains internal mechanical stops. If it is allowed to run outside of the initial factory alignment of the limit switches, a realignment of switches and feedback might be required.

Installation

INSTALLATION WIRING

Typical wiring diagrams are shown on pages 7-8. **Actual wiring should follow the print supplied with the actuator.**

The wiring diagram shows the fundamental connections for the standard three-wire reversible single-phase motor, and the standard permanent magnet dc motor. These units show an arrangement with torque switches, four limit switches, two feedback potentiometers, and a heater. To meet special requirements, certain items shown may not be supplied. **In all instances the wiring diagram appropriate to the equipment will be supplied with each unit.**

A barrier type terminal strip is located under the rear cover opposite the output shaft. Two conduit entries are located in the side of the unit to accommodate standard 1 inch N.P.T. fittings.

CAUTION: On standard single-phase wiring, the position limit switches and the torque switches are wired directly in the motor circuit and protect it at the extremes of travel or at torque cutout. Three phase AC or DC units must have these torque and position limit switches wired into the controlling device to cause end of travel or torque shutdown. Care must be taken in wiring these to the controlling device so that the appropriate direction of control is turned off when that direction's limit switch is actuated. If care is not taken in phasing the equipment, damage may occur to the actuator or driven load. Also, inductive devices, such as lights and solenoids, must not be paralleled across motor terminals 1 and 2 or 1 and 3 as this will upset the motor capacitor phase shift and motor torque will be affected.

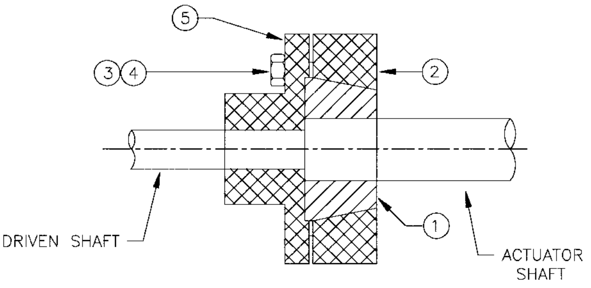
- All wiring must be done in accordance with prevailing codes by qualified personnel.
- Fusing must be installed in line power, and should be of the slow blow type.
- Wiring should be routed to the actuator through the two conduit openings. Generally, one conduit will contain input power and earth ground wires. The other conduit would then contain low level input and output signal wiring. It is required that all low level signal wiring be a shielded type with the shield grounded at source common.
- After installation, it is required that all conduits be sealed to prevent water damage and to maintain NEMA 4 enclosure and applicable dust ignition ratings.

JORDAN CONTROLS SUPPLIED (OPTIONAL) COUPLING (Field Installed)

Jordan Controls has designed a three piece "wedge-lock" coupling which can be adjusted to align the driven device to the actuator output shaft with no concern as to keyway alignment of the shaft on the drive device in relation to the spline on the actuator output shaft.

ADJUSTMENT

1. Slide coupling (5) onto driven shaft.
2. Slide coupling cone (1) and cup (2) onto actuator shaft.



3. Mount actuator with the two shafts in line and the shaft ends about inch (3 mm) apart.
4. Turn the shaft of the driven device to the close position.
5. Run the actuator to the close limit switch.
6. Lock coupling (5) to the driven shaft by pinning or other suitable method.
7. Slide cone (1) to fit flat in recess of coupling (5).
8. Install three bolts and lockwasher (3) and (4) and tighten. (20-30 ft. lbs.)
9. Operate the actuator in the open direction and back to the closed direction until the close limit switch stops the actuator.
10. If the driven shaft does not move to the exact closed position you want, loosen the three bolts and turn the driven shaft. Tighten the bolts. (20-30 ft. lbs.)

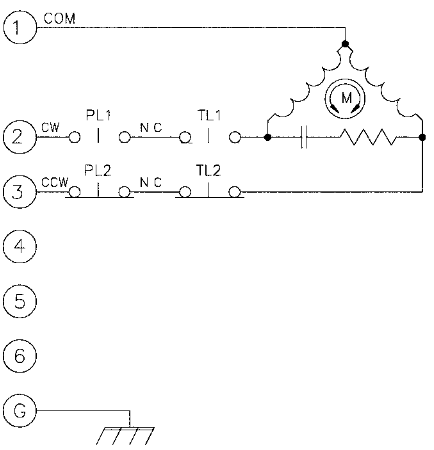
NOTE: Keep the coupling parts clean while assembling.

See page 18 of this manual for Jordan supplied linkage components information.

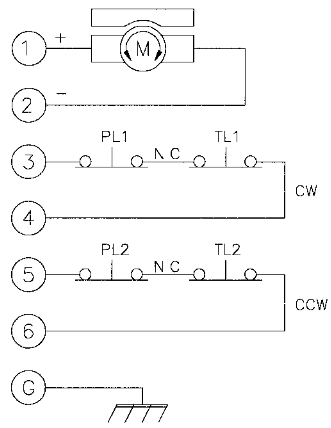
Typical Wiring Diagrams

ACTUATOR WITHOUT AN INTERNAL AMPLIFIER

SM-5120 (120 Vac)
SM-5190 (240 Vac)



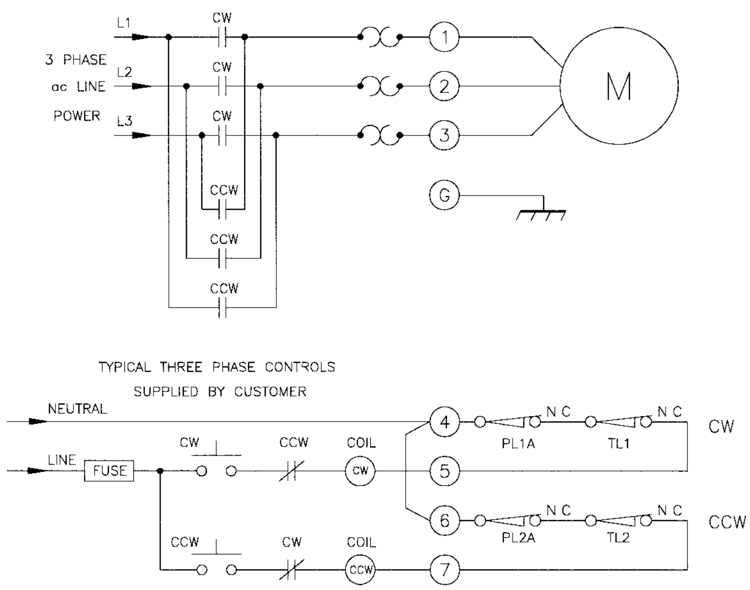
SM-5140 & SM-5160 (24 & 90 Vdc)



Actuator Action	AC Power Applied to Terminals		DC Power Applied to Terminals	
	1 & 2	1 & 3	1(+) & 2(-)	1(-) & 2(+)
Viewing Output Shaft	CCW	CW	CW	CCW

Notes: 1. The torque limit switches are factory set to trip if the rating of the actuator is exceeded.
2. Shielded wire is required for position feedback signal wiring.

SM-5115 SERIES ACTUATOR



Due to wide variations in terminal numbering of actuator products, actual wiring should follow the print supplied with the actuator.

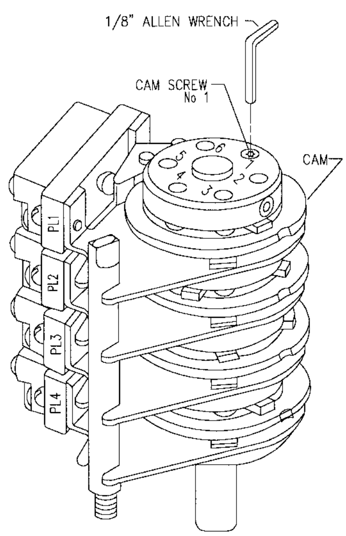
Notes: 1. Optional remote three phase reversing starter shown.
2. Caution: Care must be taken in properly phasing position and torque limit switches with respect to clockwise and counterclockwise positioning.

ACTUATORS WITHOUT SERVO AMPLIFIERS

A. POSITION LIMIT SWITCH ADJUSTMENT (Ref. Fig. 1)

NOTE:
The actuator is shipped in its mid-travel position.

1. Referring to your wiring diagram, apply motor power and drive the actuator in the CW output shaft direction (looking at the shaft), until PL1 trips and stops the actuator. This is the CW limit switch setting and starting point for final switch adjustment.
2. Move the controlled equipment to the same starting point and couple the actuator output shaft to the driven shaft.
3. Apply motor power to rotate the output shaft CCW about 5 degrees, allowing PL1 switch to reset.
4. Apply motor power to rotate the output shaft CW until PL1 trips, turning off the motor. If the driven device is not at the desired position:
   a. Remove motor power.
   b. Using an 1/8 inch, long shaft allen wrench, loosen Cam Screw #1 about 1/4 turn.
   c. Rotate Cam #1 CCW to allow the actuator to run further in the CW direction or rotate the cam CW to turn the actuator off sooner. (Cam #1 will turn off the motor for CW output shaft rotation, when the switch roller lever moves to the high side of the cam with the cam rotating CW.)
   d. Position the Cam as desired and while holding in place, tighten screw #1 with moderate force to adequately clamp the cam in place.
   DO NOT OVER TIGHTEN.



5. Apply motor power to drive the actuator to the desired CCW position or until PL2 trips and stops the motor. If the driven device is not at the desired position:
   a. Remove motor power.
   b. Loosen Cam Screw #2 about a turn.
   c. Rotate Cam #2 CW to increase the actuator's total travel range or CCW to decrease the travel range.
   d. Hold the cam in place and tighten screw #2.
6. Electrically operate the actuator to its CW limit and back to the CCW limit to check switch settings. Readjust Cam #1 or #2 as needed.
7. Switches 3 through 6 (optional) are adjusted by loosening their respective cam screws and rotating the cam. They may be set anywhere within the range of PL1 or PL2.
8. If the unit is equipped with a feedback device and switches PL1 or PL2 were readjusted, proceed with the proper feedback alignment prior to any further adjustments or operation of the actuator.

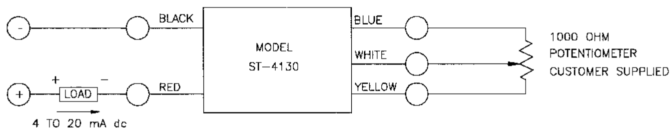
B. 1000 OHM POTENTIOMETER ADJUSTMENT

1. Run the actuator to the center of travel. Loosen the three panhead screws, securing the potentiometer body, and rotate it to its center of travel (500 ohm) position. An ohmmeter will be required for this adjustment. Tighten the three screws.
2. Run the actuator to the zero or minimum travel limit. With the actuator running, monitor the potentiometer with an ohmmeter to ensure the potentiometer deadband is not crossed.
3. If your system requires a low resistance starting point, loosen the three screws and rotate the potentiometer body for the required starting resistance. This is usually 20 to 50 ohms (measured from the potentiometer wiper arm to the zero end of the potentiometer).

C. 4 to 20mA TRANSMITTER OPTION ADJUSTMENT

The ST-4130 (1000 ohm-input, 4 to 20 mA output) two wire transmitter modulates the current on a direct current supply proportional to the input resistance. It is powered by a separate 12.0 to 36.0 Vdc regulated power supply line which is modulated from 4 to 20 mA proportional to the resistance of the input.

For the unit to function optimally, the 4mA end of the feedback potentiometer must be preset to 50 ohms.



1. Position the actuator to the desired 4mA setting.
2. With potentiometer resistance at 50 ohms, adjust ELEVATION for 4.0mA output.
3. Position the actuator to the desired 20mA setting.
4. Adjust RANGE for 20mA output.
5. Repeat steps 1 through 4 until desired accuracy is achieved.
6. To reverse the 4 and 20mA output, interchange the BLUE and YELLOW wires and return to step 1.

D. ACTUATOR WITH INTEGRAL AD-8130 SERVO AMPLIFIERS

Switch and feedback potentiometer alignment is accomplished in the same manner as actuator without amplifiers, except motor power is supplied from the amplifier. Varying the command signal input to the amplifier will allow reversal of the rotation of the actuator output shaft to run to the minimum/maximum switch settings. If the actuator does not run to the limit switch, but stops short, the amplifier has nulled and adjustments of span, elevation, loss of signal, or feedback potentiometer may be required. Refer to IM-0607 for information on the AD-8130 amplifier.

The EC-10852 is for use with the AD-8130 servo amplifier with LVDT (voltage feedback). The EC-10852 is used as the HI and LO trim for the AD-8130. The AD-8130 is factory set for operation with the EC-10852. **CAUTION: It is important not to adjust the HI and LO trim on the AD-8130, which are torque sealed at the factory**. For specific Setup information and calibration, refer to the wiring diagram supplied with your unit.

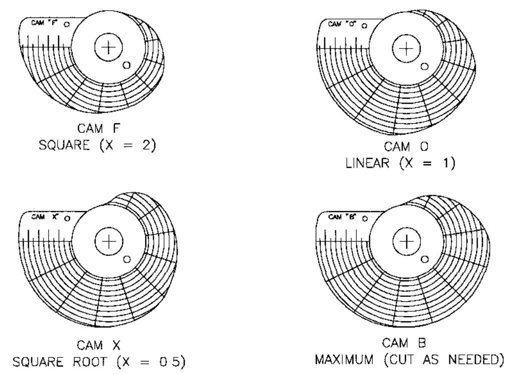
E. CHARACTERIZED CAM ADJUSTMENT (OPTION)

The characterized feedback assembly is an option which directly replaces the standard linear feedback potentiometer.

> Prior to adjusting the cam, the end of travel limit switches must be set and the proper cam installed for your particular system requirements on the characterized cam shaft. Four different cams are supplied with each characterized assembly. The cams are printed on both sides and may be flipped over to reverse the characterization action in relation to the output shaft rotation.

The cams are each printed with a letter "O", "F", or "B" which indicate the cam type. Three of the cams are shaped to correspond to X=2, 1, and 0.5 respectively in the equation:

% amplifier input = (% shaft rotation)x



The fourth cam is used for any value of x between 0.5 and 2 and must be cut by the user. For details on cutting this cam, see "To Shape Feedback Cam".

a. Run the actuator to the zero or minimum position limit. While running, observe the direction of character cam rotation.
b. Is the cam rotating in the direction of 100-0 for your system requirement? If not, remove the thumb screw and flip the cam over. Tighten the screw.
c. Have you selected the proper cam for the system requirement? If not, remove the thumb screw and change the cam, installing the cam the same as in (b) above. (Green or Black side up.)
d. Loosen three screws and remove the cam assembly.
e. Rotate the cam until the zero on the cam is in line with the center line of the potentiometer or LVDT shaft.
f. Potentiometers need no further adjustment.
g. LVDT contactless feedback may require fine zeroing.
    i. Apply power to the LVDT and monitor the output with a volt meter.
    ii. Loosen the two body clamp screws and slide the body of the LVDT to obtain zero output.
    iii. Tighten the body clamp screws.
    iv. If a finer adjustment is desired, loosen the nut on the LVDT shaft and turn the shaft slightly one way or the other and tighten the nut.

TO SHAPE FEEDBACK CAM

With characterized feedback, one of the four cams supplied (cam B), is partially shaped. For installation, it must be cut to its final shape by the user. This cam is used if none of the other three cams produces the desired input-output relationship where:

% amplifier input = (% shaft position)X

Two typical conditions where the user might want to use the fourth cam are:

1. In equation above, if the value of X is not equal to 0.5 or 2.

2. In equation, if the value of X is equal to 0.5 or 2, and if upper shaft position is not equal to 100% (90°), and/or lower shaft position is not equal to 5% (0°).

To lay out the cam shape for the desired input-output relationship, it is necessary to determine outputs (rise in cam), for various inputs (amount of cam rotation). The rise in the cam corresponds to % of maximum output range and the amount of cam rotation corresponds to % input signal to amplifier.

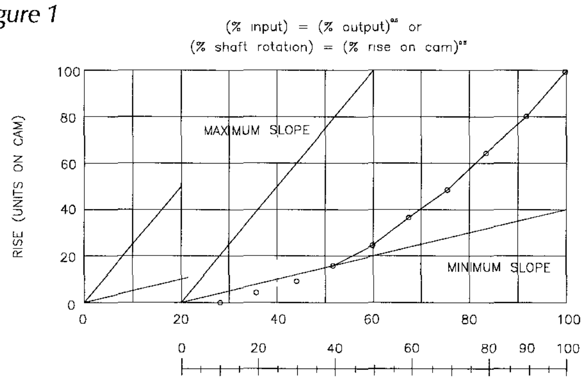
1. Lay out on graph paper, axes and maximum and minimum slopes as shown in figure 2. (Maximum slope is 25 units rise per 10% shaft rotation; minimum slope is 5 units per 10% rotation.)
2. If either upper or lower shaft position is not at 0 or 100% (0° or 90°) respectively, lay out additional x-axis scale as shown in figure 3 on page 13. Use both sets of values when plotting cam shape in step 3.
3. Calculate outputs (rise in cam) for 5% or 10% increments in input for entire input scan (actual cam rotation). NOTE: only output values that fall within maximum and minimum slope lines can be used.
4. Plot these values on cam. Scribe smooth line between points and grind cam to this shape.

Refer to example for typical cam calculations and layout.

TYPICAL FEEDBACK CAM CALCULATIONS

EXAMPLE: Assume X in (input/output equation) = 0.5, and that upper and lower shaft positions are at 100% and 20% (90° and 18°), same as center illustration of Figure 3.

Figure 1



Input	Output	
% of actual rotation	location on cam	% rise on cam
0	20%	0
10	28	1*
20	36	4*
30	44	9*
40	52	16
50	60	25
60	68	36
70	76	49
80	84	64
90	92	81
100	100	100

Note: These values fall outside of minimum slope on graph.

Figure 2

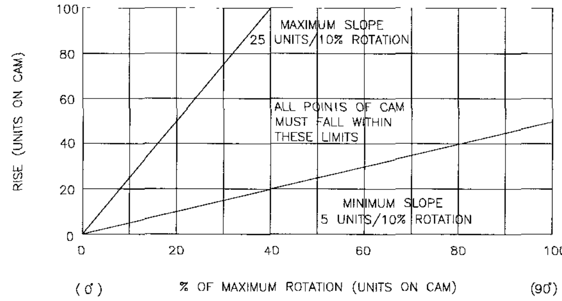
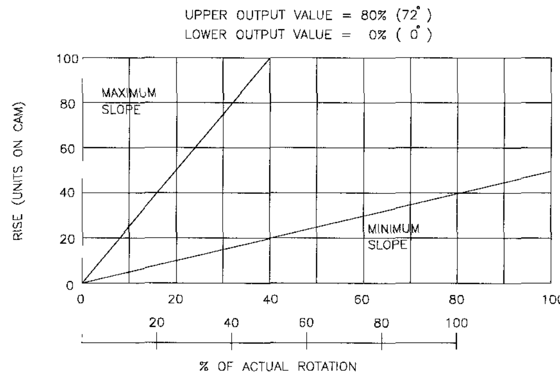
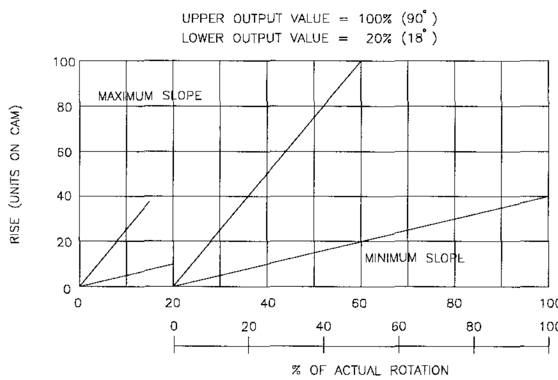


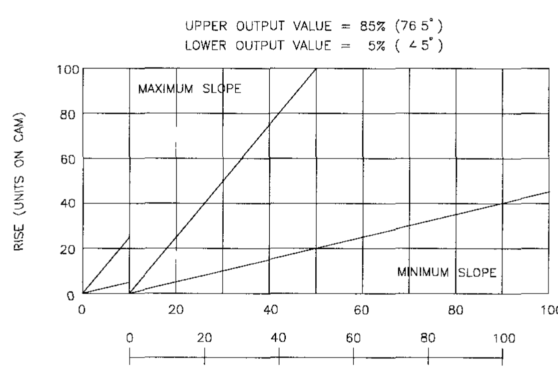
Figure 3

Illustrations below show an 80% (72°) shaft rotation span





IF LOWER SHAFT POSITION IS NOT EQUAL TO 0% (0°) REDRAW SLOPE LIMITS TO GO THROUGH ACTUAL STARTING ROTATION POINT, AS SHOWN ABOVE



IF LOWER SHAFT POSITION IS NOT EQUAL TO 0% (0°) REDRAW SLOPE LIMITS TO GO THROUGH ACTUAL STARTING ROTATION POINT, AS SHOWN ABOVE

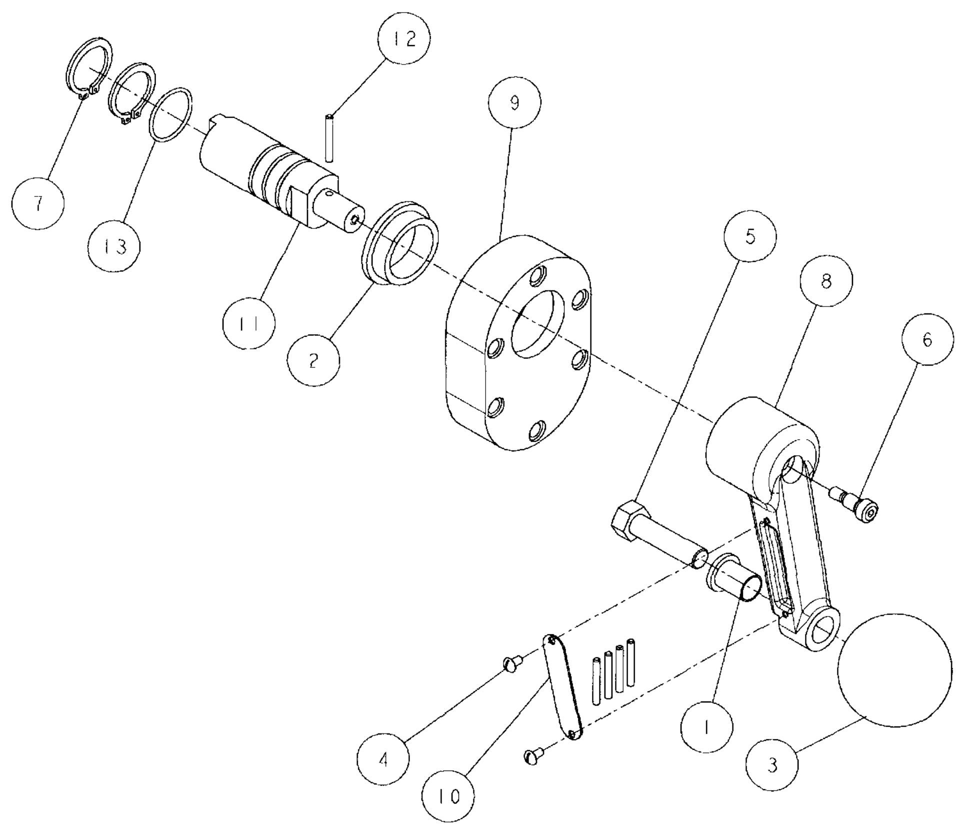
Troubleshooting Guide

TROUBLE	POSSIBLE CAUSE	REMEDY
Motor does not operate	a. No power to actuator	a. Check source, fuses, wiring
	b. Motor overheated and internal thermal switch tripped (single phase AC motors only)	b. Let motor cool and determine why overheating occurred (such as, excessive duty cycle or ambient temperature)
	c. Motor burned out	c. Replace motor and determine cause of failure
	d. Motor drag brake improperly adjusted	d. Adjust as detailed on page 20
	e. Motor drag brake defective	e. Replace drag brake
	f. Both end of travel switches open or one open and one defective	f. Adjust switch settings or replace defective switch
	g. Actuator output shaft stalled	g. Check drive load for mechanical jam and correct cause
	h. Defective motor run capacitor	h. Replace capacitor (AC models)
	i. Load exceeds actuator torque rating	i. Reduce load or replace actuator with one with appropriate torque rating
	j. Power applied to CW & CCW rotation at same time	j. Correct power input problem
	k. Amplifier defective	k. Replace amplifier
	l. Amplifier is in Loss of Signal	l. Check command signal to verify signal greater than 3.8 mA is present
	m. Amplifier deadband is too wide	m. Reduce deadband setting
Motor hums but does not run	a. Power applied to CW & CCW rotation at the same time	a. Correct power input problem
	b. Damaged power gearing	b. Repair gearing
	c. Defective motor run capacitor	c. Replace capacitor
	d. Motor drag brake	d. Adjust or replace as required
Motor runs, output shaft does not rotate	a. Defective power gearing	a. Repair gearing
Motor does not shut off at limit switch	a. Switch wired wrong or is defective	a. Correct wiring or replace switch
	b. Motor phased incorrectly	b. Correct wiring
Actuator backdrives when power is removed	a. Motor drag brake improperly adjusted	a. Adjust as detailed on page 20
	b. Motor drag brake defective	b. Replace drag brake
Handcrank does not move output shaft	a. Power still on	a. Remove power
	b. Load is jammed and motor drag brake slips	b. Remove jammed load
	c. Drag brake missing or improperly adjusted.	c. Replace drag brake

Troubleshooting Guide

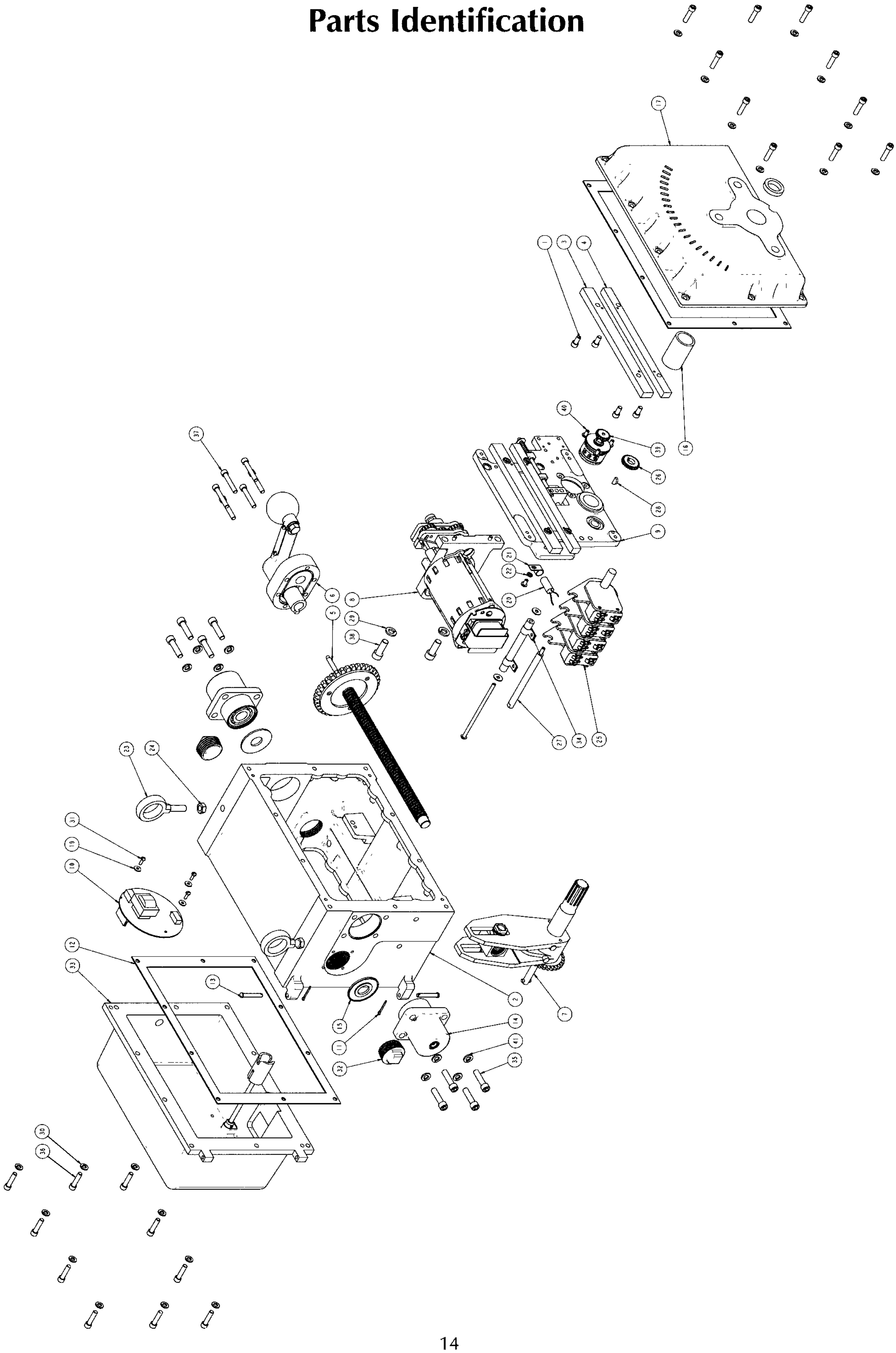
Motor runs, but only one way	a. Power not applied for other direction	a. Correct power problem
	b. Power always applied to one direction and electrically stalls when applied for opposite direction	b. Correct power problem
	c. Open limit switch for other direction	c. Adjust or replace limit switch as required
	d. Actuator is torqued out	d. Determine obstruction and correct
	e. Motor has an open winding	e. Replace motor
	f. Motor and feedback potentiometer are out of phase	f. Reverse potentiometer end leads
	g. Amplifier is defective	g. Replace amplifier
Poor response to command signal changes	a. Amplifier deadband is too wide	a. Reduce deadband setting
	b. Amplifier is defective	b. Replace amplifier
	c. Excessive noise on command signal	c. Reduce noise. Also ensure that command signal wiring is shielded with shield grounded at source common only.
	d. Defective feedback potentiometer	d. Replace potentiometer
Actuator oscillates at setpoint	a. Amplifier deadband is too narrow	a. Increase deadband setting
	b. Amplifier is defective	b. Replace amplifier
	c. Excessive noise on command signal	c. Reduce noise. Also ensure that command signal wiring is shielded with shield grounded at source common only.
Pot feedback signal not always present during actuator rotation	a. Pot not aligned with end of travel extremes and is being driven through dead region	a. Align pot to range of actuator
	b. Pot signal is erratic or nonexistent	b. Replace pot
Pot signal does not change as actuator operates	a. Defective pot	a. Replace pot
	b. Feedback gear not turning pot shaft	b. Check gearing engagement and set screw in gear hub
Pot signal is reversed for output shaft rotation	a. Pot is wired wrong	a. Reverse wiring from ends of pot at actuator terminal block
Output shaft rotates wrong direction for CW and CCW input power	a. Wiring to actuator incorrect	a. Correct field wiring
	b. Wiring from motor to terminals or switches is reversed	b. Correct internal actuator wiring
4-20 mA customer feedback missing or non-linear	a. External wiring error	a. Refer to amplifier instruction manual
	b. Power supply fault	b. Refer to amplifier instruction manual
	c. Shunt resistance too light	c. Refer to amplifier instruction manual

Parts Identification



Item	Quantity	Part Number	Description
1	1	18B-SP1988-065	BUSHING
2	1	18B-SP1988-075	BUSHING
3	1	47A-007639-001	KNOB
4	2	54A-015023-025	SCREW RD HEAD #6-32 X .25 LG
5	1	54A-015081-150	CAP SCREW HEX HEAD .38-16 X 1.50 LG
6	1	54A-015204-038	SCREW SHOULDER SOC HD .25 X .38 LG
7	2	58B-014186-098	RET. RING TRUARC #5160-59
8	1	60B-018982-001	HANDLE CRANK
9	1	60B-038887-001	HADN CRANK HOUSING MACH NEMA 4
10	1	61A-017891-001	RETAINER PLATE SHEAR PINS
11	1	61A-038877-001	SHAFT
12	5	61A-038895-001	SHEAR PIN
13	1	74B-01957-020	O-RING .88 I.D. X 1.0 O.D.

Parts Identification



Parts Identification

Item	Quantity	Part Number	Description
1	4	54A-015060-050	CAPSCREW SOC HD .25-20 x .50 LG.
2	1	60D-019010	CASTING CENTER
3	1	61B-011412-001	SUPPORT RAIL
4	1	61B-011882-001	SUPPORT RAIL
5	1	68B-018992	DRIVE GEAR ASSEMBLY
6	1	68B-038894-001	HANDLE ASSEMB;Y
7	1	68C-036204	OUTPUT SHAFT ASSEMBLY
8	1	68C-038912	AC MOTOR ASSEMBLY WITH DRAG
9	1	68D-036211	CENTER SUPPORT ASSEMBLY
10	1	68C-035819-001	AMPLIFIER PCB ASSEMBLY
11	2	57A-033270-019	COTTER PIN
12	2	13C-017985-002	DOOR GASKET
13	2	74A-017486-001	COVER HINGE PIN
14	2	68A-017205	END CAP HOUSING
15	2	74B-010957-033	END CAP SEAL
16	1	18B-003814-035	FRONT BUSHING
17	1	60D-017257-001	FRONT COVER
18	1	19B-003815-002	FRONT SEAL
19	3	58B-024244-095	GENERIC TYPE B FLAT WASHER
20	1	74A-016946	HEATER
21	1	74A-016947-001	HEATER CLIP
22	1	54A-015033-038	HEATER SCREW
23	2	58B-024244-002	EYE BOLT
24	2	55A-015089-001	GENERIC REGULAR HEX NUT
25	1	68D-021669	LIMIT SWITCH ASSEBLY
26	1	61A-025809-001	LIMIT SWITCH GEAR
27	1	62A-021667-002	ANCHOR SHAFT
28	1	58B-016181-006	LIMIT SWITCH KEY
29	2	56A-015231-001	WASHER .38
30	20	56A-015211-001	SPLIT RING
31	3	54A-015023-063	GENERIC PAN HEAD SCREW
32	2	52A-024353-001	PIPE PLUG
33	1	60D-017481	REAR COVER ASSEMBLY
34	2	33B-003852	RESISTOR CLIP
35	8	54A-015070-100	SKT HD SCR .31 X 1.25
36	20	54A-015060-100	SKT HD SCR .25 X 1.5
37	6	54A-015060-075	SKT HD SCR .25 X 1.5
38	2	54A-015080-150	SKT HD SCR .38 X 1
39	1	68A-007162	SWITCH ASSEMBLY
40	4	54A-015032-025	SWITCH ASSEMBLY SCREW
41	8	56A-015221-001	WASHER .31

Maintenance

LUBRICATION

Under normal service conditions the motor, gearing, bearings, and parts are all pre-lubricated and should not require periodic maintenance. If for any reason the unit is disassembled in the field, all oilite bushings should be resaturated with an SAE-10, non-detergent oil and all gearing heavily coated with Amoco Rykon Premium Grease #2 or equivalent grease. Care should be taken to ensure that no foreign material is allowed to become combined with the grease in the gear train, which will cause premature failure. Keep gearbox clean and dry.

DRAG BRAKE ADJUSTMENT

The drag brake serves two functions: a) to prevent actuator from backdriving at maximum rated torque; and b) to allow the motor shaft to slip when handcranking and the output shaft load is in excess of rated torque.

The drag brake was factory set and should not need readjustment. If it does need adjustment:

1. Apply an overhung load, equal to the maximum torque rating to the output shaft.
2. Loosen drag brake jam nut until the motor shaft starts to backdrive.
3. Tighten the drag brake jam nut just enough to prevent backdriving.
4. While handcranking against the load, increase the load until motor backdriving occurs.

TORQUE LIMIT SWITCH ALIGNMENT

The torque limit switches are factory set and field adjustment is not advised unless proper test equipment is available. If adjustment must be done, use the following procedure:

1. Load the output shaft with a known load which matches the torque rating of the actuator in an opposing direction for the switch being adjusted.
2. Apply power to the motor and run the actuator to drive the opposing load.
3. Increase the load by 5% to 10% and adjust the set screw (140C) to trip the torque switch.
4. Remove the 5% to 10% increase of load and the switch should reset.
5. Load the actuator in the opposite direction and set the other switch in the same manner.

NOTE: When looking at the torque limit switch assembly as it is mounted in the actuator, the switch on the top of the assembly controls the CW torque and the switch on the bottom controls the CCW torque. The torque should be set near equal for both directions.

When the actuator is driven into a torque condition in the CW direction (looking at the output shaft), the handcrank handle will move slightly outward. For CCW direction the handle will pull slightly inward.

Maintenance

MOTOR REPLACEMENT

1. Disconnect all power to the actuator.
2. Remove screws, washers and rear cover.
3. Disconnect actuator output shaft from driven device and remove actuator from mount.
4. Remove bolts, washers, and front gear case cover. Note location of all gearing.
5. Remove motor pinion.
6. Remove brake assembly from top of motor.
7. Disconnect motor wires - note colors.
8. Remove motor.
9. Reverse the procedure to install new motor. (Clean and regrease all gearing, check bushings and bearings, lubricate bushings with SAE-10, non-detergent oil.)
10. Reinstall the actuator.

POWER GEARING REPLACEMENT

1. Perform steps 1,3 & 4 of Motor Replacement.
2. Remove defective gear(s) and replace with new.
3. Ensure all gearing and oilite bushings are properly lubricated as detailed above.
4. Install front cover and Reinstall actuator.

POSITION LIMIT SWITCH REPLACEMENT

1. Disconnect all power to the actuator.
2. Remove rear cover.
3. Remove two screws and washers from appropriate switch on assembly.
4. Install new switch and transfer wires from old switch one at a time.
5. No realignment should be necessary.

FEEDBACK POTENTIOMETER REPLACEMENT

A. One Turn Linear Potentiometer

1. Disconnect all power to the actuator.
2. Remove screws, washers, and rear cover.
3. Remove three screws holding potentiometer and disc to housing.
4. Pull potentiometer and disc out of housing.
5. Measure location of gear from mounting disc to farthest face of gear and note measurement.
6. Loosen set screws and remove gear.
7. Remove nut and washer holding potentiometer to disc.
8. Cut shaft of new potentiometer to same length as old.
9. Mount new potentiometer on disc, tighten potentiometer nut, install gear to measured dimension from step 5.
10. Install assembly in housing and tighten screws.
11. Using a 25 watt solder iron, remove wires from old potentiometer one at a time and solder to corresponding terminals on new potentiometer.
12. Align potentiometer and install cover.

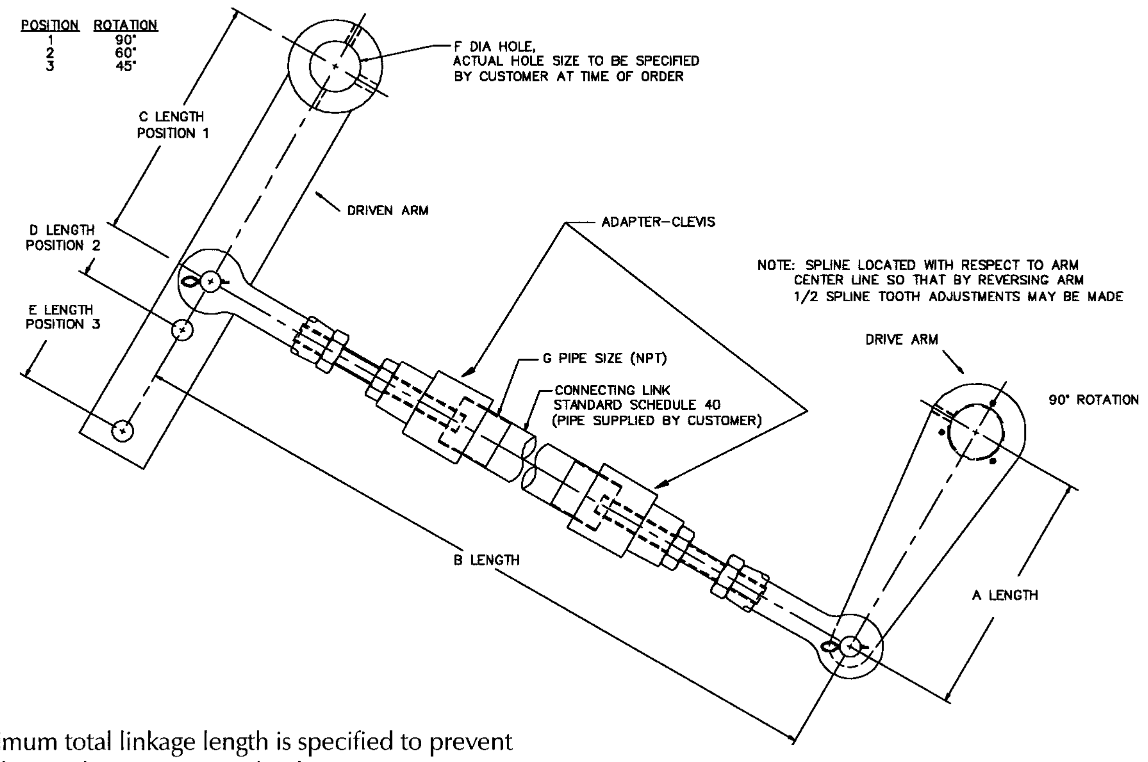
B. Characterized Potentiometer

1. Disconnect power and remove rear cover.
2. Remove three screws and pull potentiometer off of pins.
3. Install new potentiometer and tighten screws.
4. Using a 25 watt solder iron, remove wires from old potentiometer one at a time and solder to corresponding terminals on new potentiometer. **CAUTION - DO NOT USE EXCESSIVE HEAT WHEN SOLDERING.**
5. Align potentiometer and install cover.

C. LVDT Assembly Replacement

1. Same as Characterized Potentiometer replacement above.
2. Align LVDT body for zero output (see alignment procedure, characterized cam adjustment on page 12, step G).

SM-5000 SERIES DRIVE ARM AND LINKAGE OPTIONS

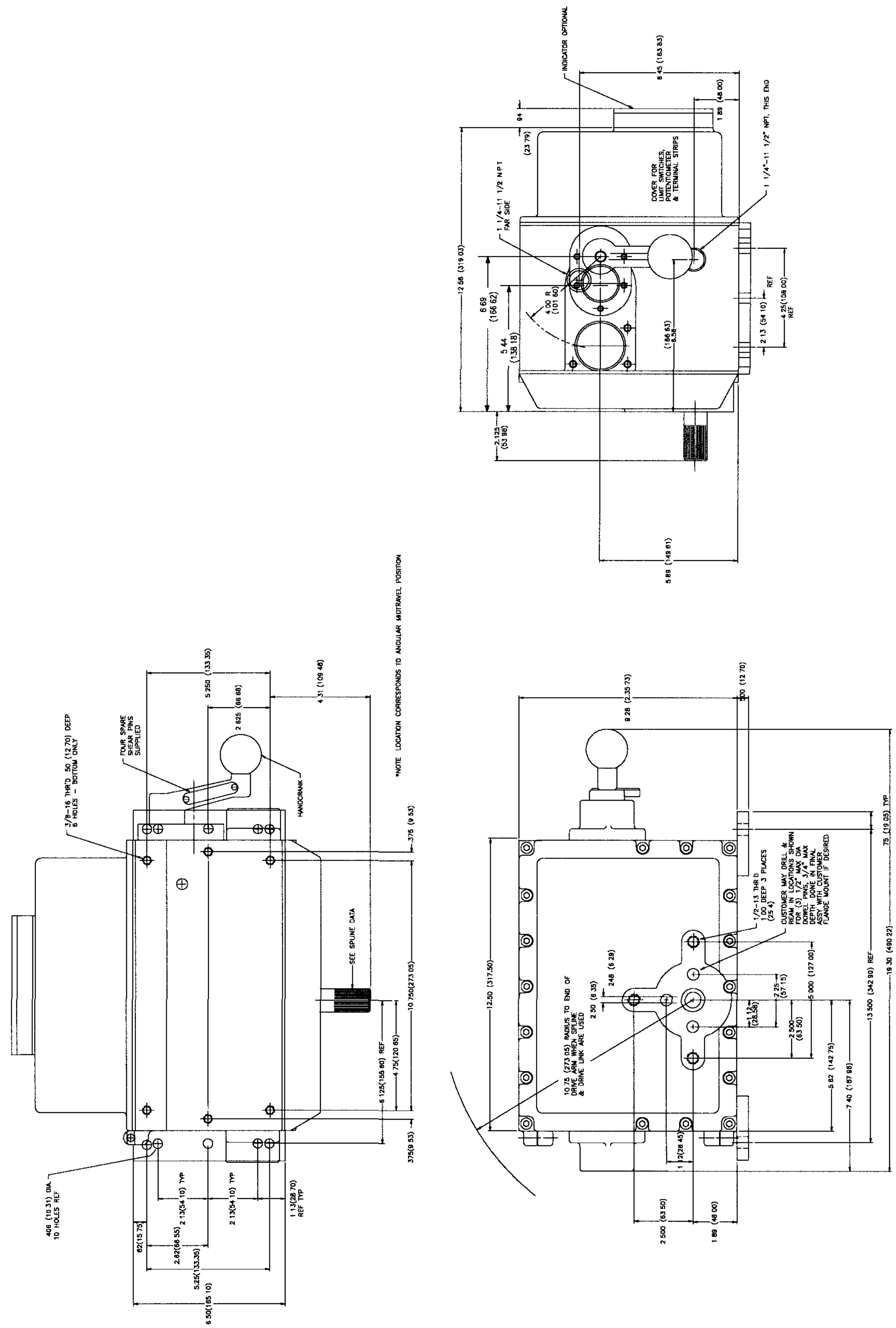


Notes:

1. Maximum total linkage length is specified to prevent buckling under compressive load.
2. Adjustable drive arms are also available to allow "A" length to vary from 6 to 10 inches (152 to 254 mm). In this case, the adapter-clevis has rod ball ends with lubricating fittings.
3. Special drive arm lengths are available to meet application requirements.

"A" LENGTH in. (mm) (See Note 3)	"B" LENGTH ft. (m)	"C" LENGTH in. (mm)	"D" LENGTH in. (mm)	"E" LENGTH in. (mm)	"F" DIA. HOLE min.-max. in. (mm)	"G" PIPE SIZE
10 (254)	18 (5.5)	10 (254)	12.25 (311)	17 (432)	0.75 - 1.5 (19 - 38.1)	1 - 1/4 (NPT)

Major Dimensions



These dimensions are subject to change without notice and should not be used for preparation of drawings or fabrication of installation mounting. Current installation dimension drawings are available on request.

The dimensions in this manual are subject to change without notice and should not be used for preparation of drawings or fabrication of installation mounting. Current installation dimension drawings are available upon request.

JORDAN CONTROLS, INC.
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Milwaukee, Wisconsin 53218
Phone: (414) 461-9200
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E-Mail: jordan@jordancontrols.com
IM-0422 4/01

Jordan CONTROLS

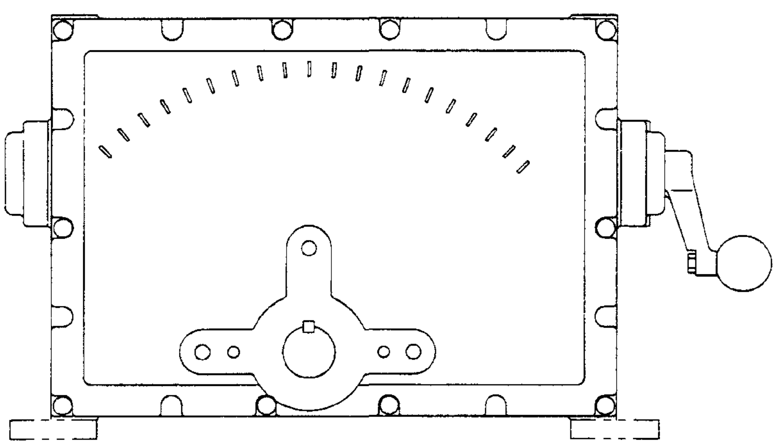
IM-0464

Jordan Controls, Inc.

SM-5200 SERIES

Instruction Manual

ELECTRIC ROTARY ACTUATOR



Due to wide variations in the terminal numbering of actuator products, actual wiring of this device should follow the print supplied with the unit.

Jordan CONTROLS

GENERAL INFORMATION

TABLE OF CONTENTS

IDENTIFICATION LABEL

An identification label is attached to each actuator cover. The serial number is also stamped on the aluminum housing, directly above the conduit entry. When ordering parts, requesting information, or service assistance, please provide all of the label information.

EXAMPLE:
MODEL NUMBER SM 52 10
CODE: SM5210
SERIAL: 1627C92-23456-1
PH/HZ/V/A: 1/60/120/1

MODEL NUMBER: SM52 10

Actuator Series — Motor Type

CODE: SM5210

Model Series

SERIAL NUMBER: 1627 C 92 - 23456-1

Sequential Number — Job Reference No.
Month built — Year built

PH/HZ/V/A: 1/60/120/1
PH=Phase
HZ=Hertz
V=Voltage
A=Amp

RECEIVING

Once you have received the actuator(s), carefully inspect for shipping damage. Damage to the shipping carton is usually a good indication that it has received rough handling.

All damage should be immediately reported to the freight carrier and Jordan Controls, Inc.

INSPECTION

Carefully unpack the actuator(s)— taking care to save the shipping carton and any packing material should return be necessary. Verify that the items on the packing list or bill of lading agree with your own.

STORAGE

If the actuator(s) will not be installed immediately, they should be stored in a clean, dry area where the ambient temperature is not less than -20° F. The actuator(s) should not be stored in a corrosive environment.

EQUIPMENT RETURN

For your convenience Jordan Controls, Inc. will provide an efficient method of returning equipment for repair.

Returned Goods Authorization

A returned goods authorization (RGA) number is required to return any equipment for repair. This must be obtained from the Jordan Controls Service Department. The equipment must be sent to the following address after the RGA number is issued:

Jordan Controls, Inc.
5607 West Douglas Avenue
Milwaukee, Wisconsin 53218
Attn: Service Department

To facilitate quick return and handling of your equipment include:
RGA Number
Your Company Name
Address
Repair Purchase Order Number
Brief description of the problem

INTRODUCTION AND GENERAL DESCRIPTION

INTRODUCTION

Jordan Controls, Inc., designs, manufactures and tests its products to meet many national and international standards. However, for these products to operate within their normal specifications, you must properly install, use and maintain these products. The following instructions must be adhered to and integrated with your safety program when installing, using and maintaining Jordan Controls products:

- Read and save all instructions prior to installing, operating and servicing this product.
- If you do not understand any of the instructions, contact your Jordan Controls representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation and maintenance of the product.
- Install your equipment as specified on Jordan Controls installation instructions and per applicable local and national codes. Connect all products to the proper electrical sources.
- Handle, move and install each product using the appropriate number of personnel and moving devices/equipment (dolly, forklift, crane, etc.). Failure to do so could cause serious personal injury.
- To ensure proper performance, use qualified personnel to install, operate, update, tune and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Jordan Controls. Unauthorized substitutions may result in fire, electrical shock, other hazards, or improper equipment operation.
- Keep all actuator protective covers in place, (except when maintenance is being performed by qualified personnel), to prevent electrical shock, personal injury, or damage to the actuator.

CAUTION

Before installing the actuator, make sure the actuator supplied is suitable for the intended application with respect to environmental conditions and the voltage/frequency of available line power. If you are unsure of the suitability of this equipment for your installation, consult Jordan Controls prior to proceeding.

WARNING— SHOCK HAZARD

Installation and servicing must be performed only by qualified personnel. De-energize all sources of power BEFORE removing the actuator cover. KEEP COVER TIGHT WHEN CIRCUITS ARE ALIVE. Failure to follow these precautions may result in serious injury.

GENERAL DESCRIPTION

The SM-5200 series is a line of heavy duty, electrically operated rotary actuators. Available with output torque ratings of up to 1000 foot-pounds (1356 NM) and with or without a built-in servo amplifier, they provide a complete range of positioning control for both indoor and outdoor installations.

These rugged actuators were designed to provide years of maintenance-free operation, modulating the control element in process industries.

BASIC MODELS

SM-5210
240/480 Vac, 3 phase, 50/60 Hz, running current 1.8/.9A, stall current 10.3/5.2A.
Duty cycle
600 ft-lbs output: modulating
1000 ft-lbs output: 20%, maximum 5 minute on-time
Control Compatibility: Three phase bi-directional motor contactor or controller.

SM-5220
120/240 Vac, 1 phase, 50/60 Hz, running current 7.0/3.5A, stall current 13.2/6.6A.
Duty cycle
600 ft-lbs output: modulating
1000 ft-lbs output: 20%, maximum 5 minute on-time
Control Compatibility: Jordan Controls model MT-6220 meter with remote control, model CS-7200 control station, models AD-8823 or AD-8843 servo amplifiers.

SM-5220/AD-8823
120 Vac, 1 phase, 50/60 Hz, running current 7.0A, stall current 13.2A.
Duty cycle
600 ft-lbs output: modulating
1000 ft-lbs output: 20%, maximum 5 minute on-time
Control Compatibility: 4 to 20 mA dc command signal capable of driving a 470 ohm load. Other command signal ranges are available - please consult the factory.

SM-5220/AD-8843
240 Vac, 1 phase, 50/60 Hz, running current 3.5A, stall current 6.6A.
Duty cycle
600 ft-lbs output: modulating
1000 ft-lbs output: 20%, maximum 5 minute on-time
Control Compatibility: 4 to 20 mA dc command signal capable of driving a 470 ohm load. Other command signal ranges are available - please consult the factory.

SM-5260
90 Vdc, (permanent magnet field), 4.7A.
Duty cycle
600 ft-lbs output: modulating
1000 ft-lbs output: 20%, maximum 5 minute on-time
Control Compatibility: Jordan Controls model AD-7300-A (90 Vdc output), servo amplifier.

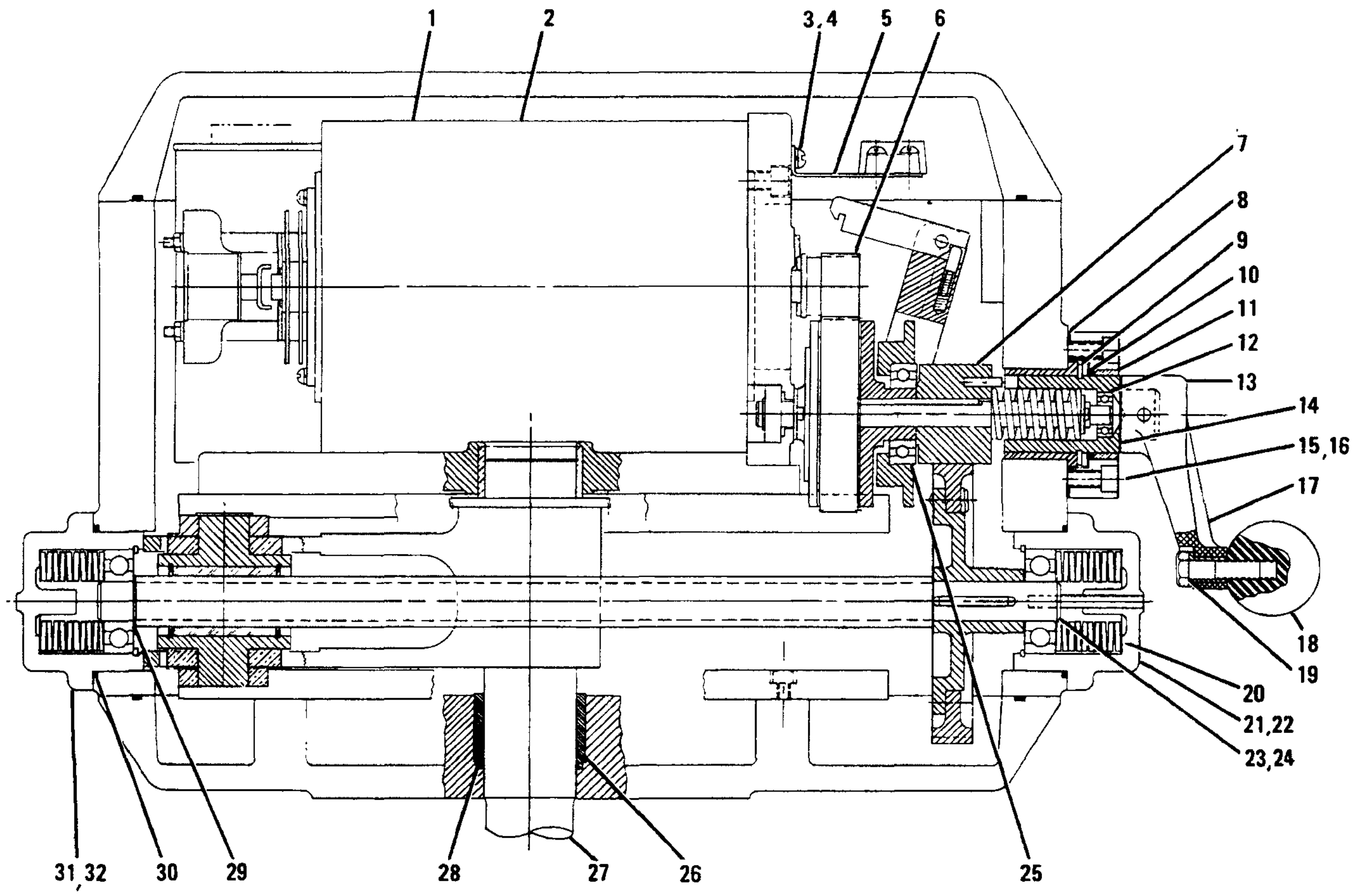


Figure 1

Item	Description	Stock No.	Qty.
1-	SM-5201 Main Assy.	70E-014137	
-1	Motor Bracket Assy, ... (SM-5210)	68C-014120-001	1
	Motor Bracket Assy, ... (SM-5220)	68C-014120-002	1
	Motor Bracket Assy, ... (SM-5260)	68C-014120-003	1
-2	Motor, AC, SM-5210	23D-014664-002	1
	Motor, AC, SM-5220	23D-014664-001	1
	Motor, DC, SM-5260	23D-012363-001	1
-3	Screw, Rd Hd,. . . . . 10-24 x 0.50"	54A-015043-050	2
-4	Washer, Lock	56A-015201-001	2
-5	Bracket, Terminal.	13B-015804-001	1
-6	Pinion Assy	68A-011657-002	1
-7	Clutch Assy,. . . . . 20 sec./30 sec.	68B-015831-001	1
	Clutch Assy, 50 sec.	68B-018567-001	1
-8	Gasket	74A-011648-001	1
-9	Ring, Retaining . . . . (Truarc 5160-98)	58B-014186-150	1
-10	O-Ring	74B-012708-222	1
-11	Bushing	18B-003814-038	1
-12	Bearing.	17B-003813-007	1
-13	Handcrank Assy.	68B-015434-001	1
-14	Shaft, Override, Manual	61A-010931-001	1
-15	Screw, Cap, Soc Hd. . . . . . . 5/16-18 x 1-1/4"	54A-015070-125	12
-16	Washer, Lock, 5/16.	56A-015221-001	12
-17	Handcrank.	60B-010978-002	1
-18	Knob.	47A-007639-001	1
-19	Bushing	18B-SP1988-065	1
-20	Washer, Belleville	56B-010462-004	20
-21	Overload Cap Assy	68B-014671-001	1
-22	Cap, Overload	60B-014670-002	1
-23	Drive Screw Assy, 20 sec. . . .	68B-018576-001	1
	Drive Screw Assy, 30 sec. . . .	68B-018576-002	1
	Drive Screw Assy, 50 sec. . . .	68B-018576-003	1
-24	Screw Drive Sub-Assy, ... 20 sec.	68B-018561-001	1
	Screw Drive Sub-Assy, ... 30 sec.	68B-018561-002	1
	Screw Drive Sub-Assy, ... 50 sec.	68B-018561-003	1
-25	Bearing, Ball.	17B-003813-031	1
-26	Bearing, Sleeve, ... 1-3/4 x 2-1/8 x 1-1/2	68D-014059-001	1
-27	Output Shaft Assy	68D-014059-001	1
-28	O-Ring	74B-012708-224	1
-29	Ring, Retaining . . . . (Truarc 5160-59)	58B-014183-078	1
-30	O-Ring	74B-010953-232	2
-31	Overload Cap Assy	68B-014671-003	1
-32	Cap, Overload	60B-014670-001	1

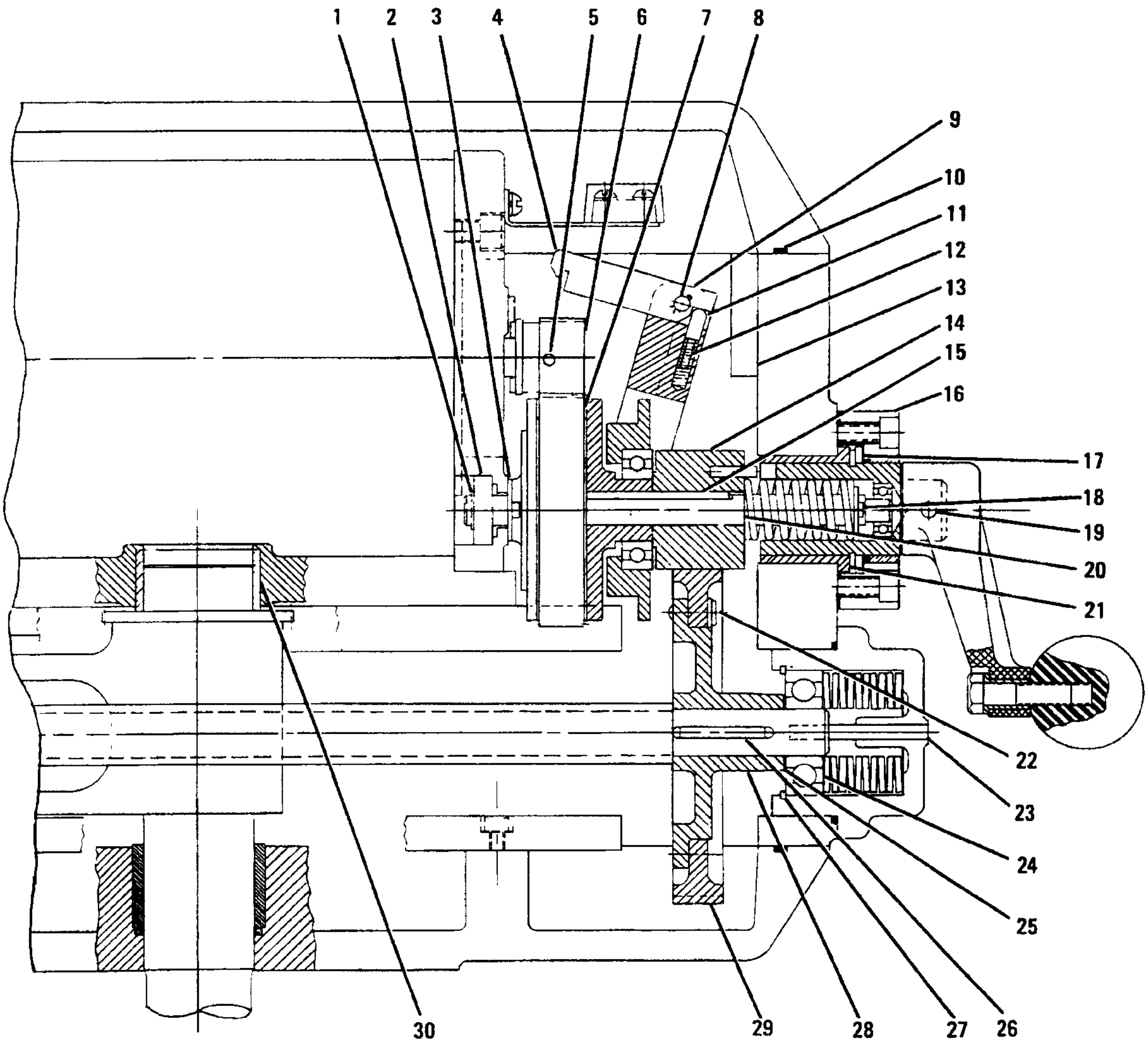


Figure 2

Item	Description	Stock No.	Qty.
2-1	Ring, Retaining	58B-014183-050	1
-2	Bearing	17B-003813-004	1
-3	Washer, Thrust	56B-004107-011	1
-4	Latch, Crank, Manual.	61A-015503-001	1
-5	Pin, Roll,.	57A-015185-125	1
	0.125 Dia. x 1.25"		
-6	Key, 3/16 Sq. x 1"	61B-010954-332	1
-7	Gear, Fiber	16B-003806-019	1
-8	Pin, Clevis	74A-016258-001	1
-9	Pin, Cotter, ...	COML	1
	3/32 Dia. x 1/2"		
-10	String, O-Ring, 112.5"	74B-010957-995	1
-11	Pin, Latch	61A-011664-001	1
-12	Spring	20A-012337-001	1
-13	Damper, Yoke.	61A-012091-001	1
-14	Gear, Slide, ...	68A-016468-001	1
	20 sec./30 sec.		
	Gear, Slide, 50 sec.	68A-018566-001	1
-15	Key, 1/8 Sq. x 2.75"	61B-010954-288	1
	20 sec./30 sec.		
	Key, 1/8 Sq. x 2.8".	61B-010954-292	1
	50 sec.		

Item	Description	Stock No.	Qty.
-16	Cap	60B-010926-001	1
-17	Washer	61A-013829-001	1
-18	Pin, Cotter, ...	COML	1
	0.130 Dia. x 3/4"		
-19	Pin, Roll,.	57A-015215-150	1
	0.25 Dia. x 1.5"		
-20	Shaft, Clutch	62A-015825-001	1
-21	Bearing, Flanged	18B-SP1988-056	1
-22	Rivet, Pop	USM-A-610-50	6
-23	Bushing	18B-003814-016	1
-24	Bearing.	17B-003813-003	2
-25	Spacer	13A-014549-003	1
-26	Key, 3/16 Sq. x 1-3/16"	61B-010954-338	1
-27	Ring, Retaining	58B-014184-206	2
-28	Hub, Gear	60B-018548-001	1
-29	Gear, 88T, 16P, 20°PA, ...	16A-013290-001	1
	20 sec./30 sec.		
	Gear, 97T, 16P, 20°PA, ...	16A-017308-001	1
	50 sec.		
-30	Bearing, Sleeve	18B-003814-048	1

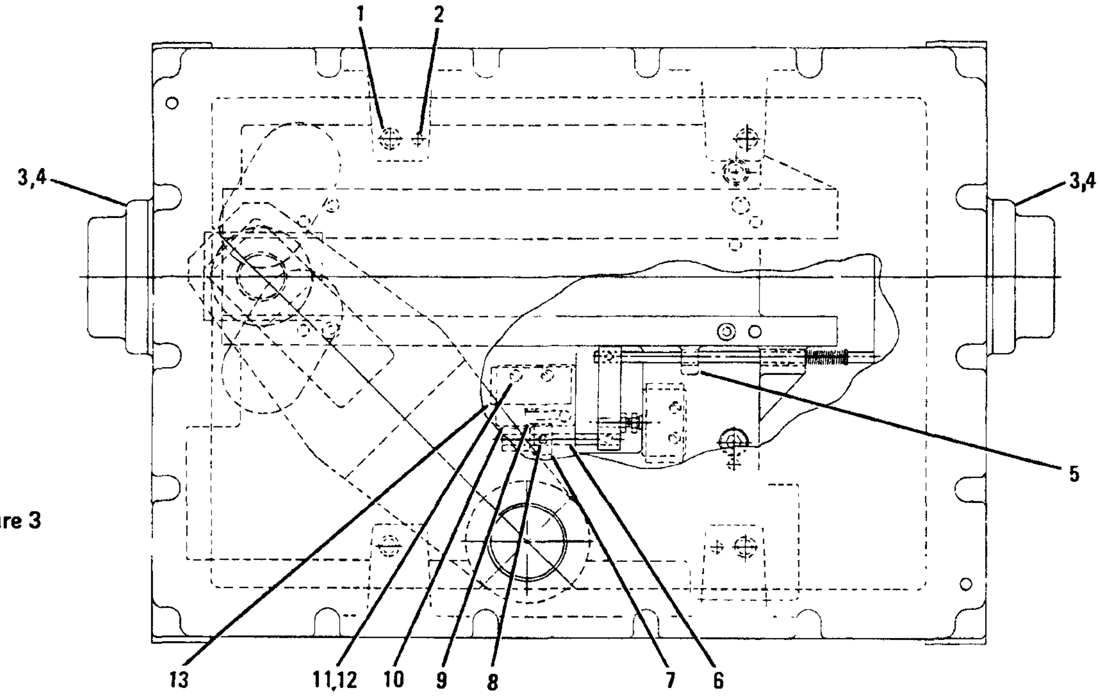


Figure 3

Item	Description	Stock No.	Qty.
3-1	Screw, Cap, Soc Hd, ... 5/16-18 x 1"	54A-015070-100	4
-2	Pin, Dowel, ... 0.25 Dia. x 1"	57A-015226-100	6
-3	Screw, Cap, Soc Hd, ... 5/16-18 x 1-1/4"	54A-015070-125	8
-4	Washer, Lock, 5/16	56A-015221-001	8
-5	Bushing	18B-003814-003	1
-6	Shaft, Switch Acutating	62A-014783-001	1.
-7	Collar, Switch Actuating	61A-018266-011	1
-8	Setscrew, Soc Hd,. . . . . 10-24 x 0.19"	54A-015047-019	4
-9	Switch, Actuator	14A-009192-001	1
-10	Insulator, Switch	61A-014784-001	2
-11	Screw, Rd Hd,. . . . . 6-32 x 1-1/4"	54A-015023-125	4
-12	Washer, Lock	56A-015180-001	4
-13	Switch, Limit . . . . (SM-5210, SM-5220)	46A-010016-001	2
	Switch, Limit . . . . (SM-5260)	46A-010016-003	2

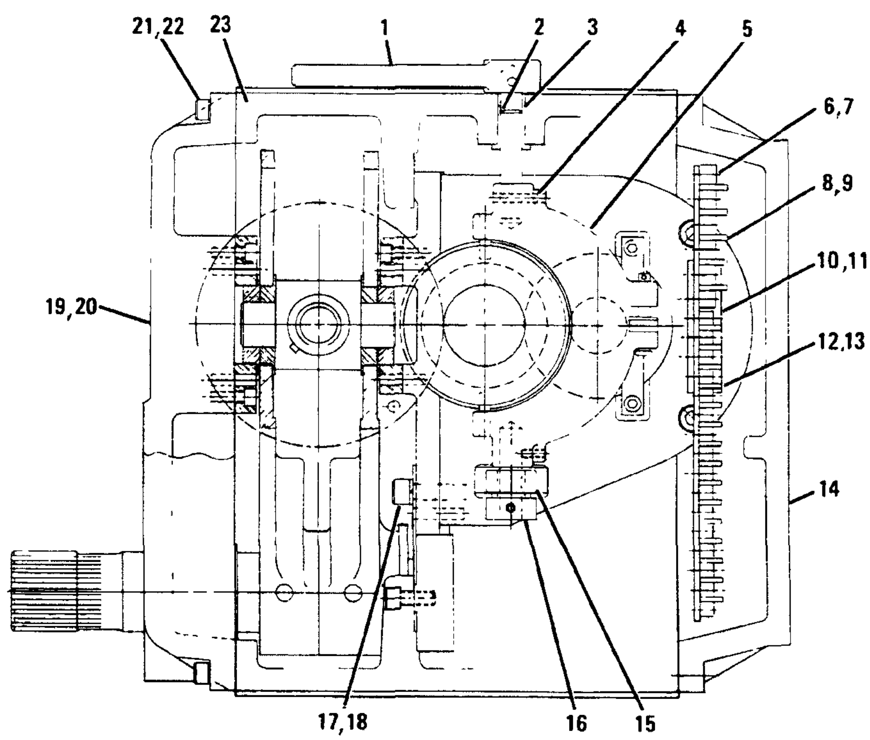
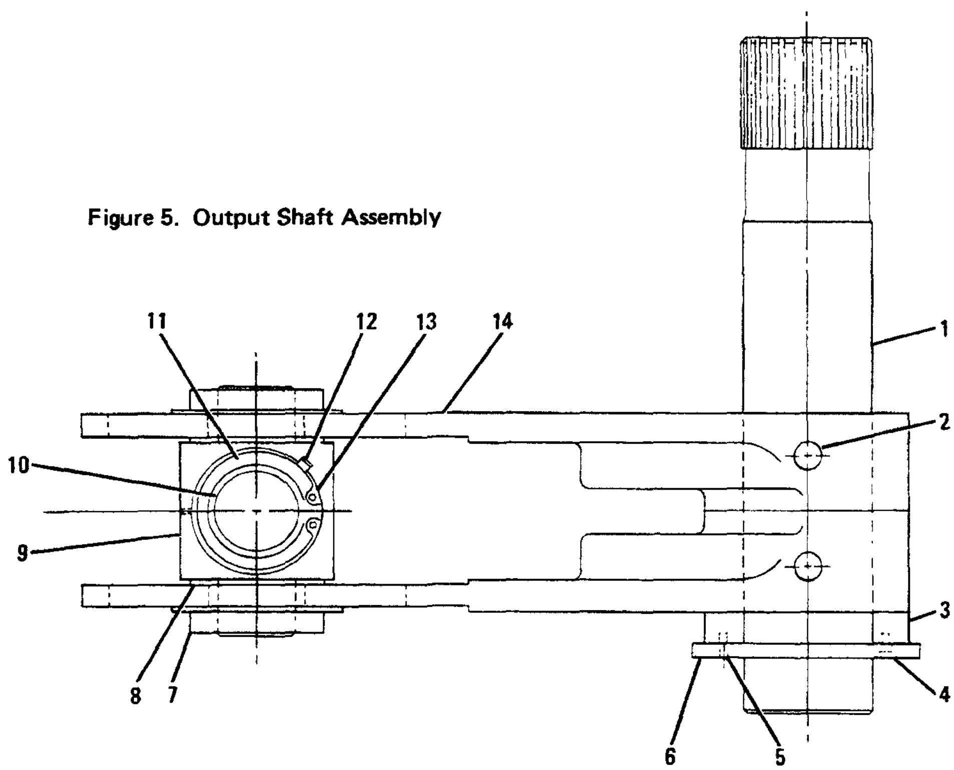


Figure 4

Item	Description	Stock No.	Qty.
4-1	Lockout Handle Assy.	68A-015493-001	1
-2	O-Ring	74B-010957-012	1
-3	Bearing.	18B-SP1988-042	1
-4	Pin, Roll,. . . . . 3/16 Dia. x 1"	57A-015205-100	1
-5	Yoke Assy	68C-015502-001	1
-6	Screw, Rd Hd,. . . . . 10-24 x 5/8"	54A-015043-062	4
-7	Washer, Lock	56A-015201-001	4
-8	Strip, Terminal, 4 Pin.	43B-003888-504	1
-9	Insulator	32A-014123-004	1
-10	Screw, Rd Hd,. . . . . 8-32 x 1/2"	54A-015033-050	4
-11	Washer, Lock	56A-015191-001-	4
-12	Strip, Terminal, 14 Pin.	43B-003888-314	1
-13	Insulator	32A-014123-003	1
-14	Cover, Back,. . . . . Weathertight	60D-010906-001	1
	Cover, Back,. . . . . Explosion-proof	60D-010906-003	1
-15	Bearing.	18B-SP1988-037	1
-16	Collar.	74A-012377-002	1
-17	Screw, Soc Hd, ... 3/8-16 x 1-1/4"	54A-015080-125	2
-18	Washer, Lock	56A-015281-001	2
-19	Front Cover Assy, ... Weathertight	68B-014130-001	1
	Front Cover Assy,. . . . . Explosion-proof	68B-014130-003	1
-20	Cover, Front.	60D-014061-001	1
-21	Screw, Cap, Soc Hd, ... 3/8-16 x 1-1/4"	54A-015080-125	36
-22	Washer, Lock	56A-015231-001	36
-23	Housing, Main, ... Weathertight	60D-012276-001	1
	Housing, Main, ... Explosion-proof	60D-012276-004	1

Figure 5. Output Shaft Assembly



Item	Description	Stock No.	Qty.
5-	Output Shaft Assy . . . . (See Fig. 1-27)	68D-014059-001	1
-1	Shaft, Output, Splined . . . . . (SM-5210)	62B-014055-001	1
	Shaft, Output, Keyway. . . . . (SM-5220, SM-5260)	62B-014056-001	1
-2	Pin, Roll,. . . . . 3/8 Dia. x 2.05"	57A-015235-250	2
-3	Spacer, Gear.	61A-017199-001	1
-4	Screw, Flat Hd . . . . 6-32 x 0.5"	54A-015024-050	3
-5	Pin, Roll,. . . . . 1/8 Dia. x 0.75"	57A-015185-075	2
-6	Gear, 144T, 48P	16B-003804-109	1
-7	Bearing.	17A-016100-001	2
-8	Bearing.	18A-010919-001	2
-9	Carrier, Nut	60C-014384-001	1
-10	Nut, Drive, 1-5 . . . . (SM-5210, SM-5220)	14A-010955-002	1
	Nut, Drive, 1-8 . . . . (SM-5260)	61A-012784-002	1
-11	Spacer, Drive Nut.	74A-014777-001	2
-12	Key, 0.187 Sq. x 2"	61B-010954-364	1
-13	Ring, Retaining . . . . (Truarc N5000-138)	58B-014184-138	2
-14	Arm, Pivot.	60C-014780-001	2

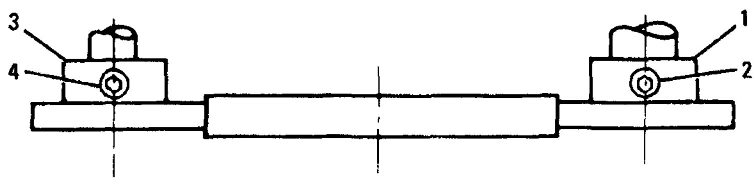


Figure 6. Feedback Gearing

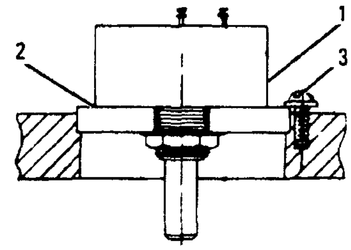


Figure 7. Standard Feedback – Potentiometers

Item	Description	Stock No.	Qty.
6-1	Gear	16A-014020-001	1
-2	Setscrew, 10-24 x 3/16"	54A-015047-019	1
-3	Gear	16B-003803-022	1
-4	Setscrew, 8-32 x 3/16"	54A-015047-019	1

Item	Description	Stock No.	Qty.
7-1	Potentiometer, ... Precision, One-Turn, 1K	34A-015848-001	1
-2	Disk, Adapter	61A-SM3304-003	1
-3	Screw, Truss Hd, ... 8-32 x 0.25"	54A-015032-025	2

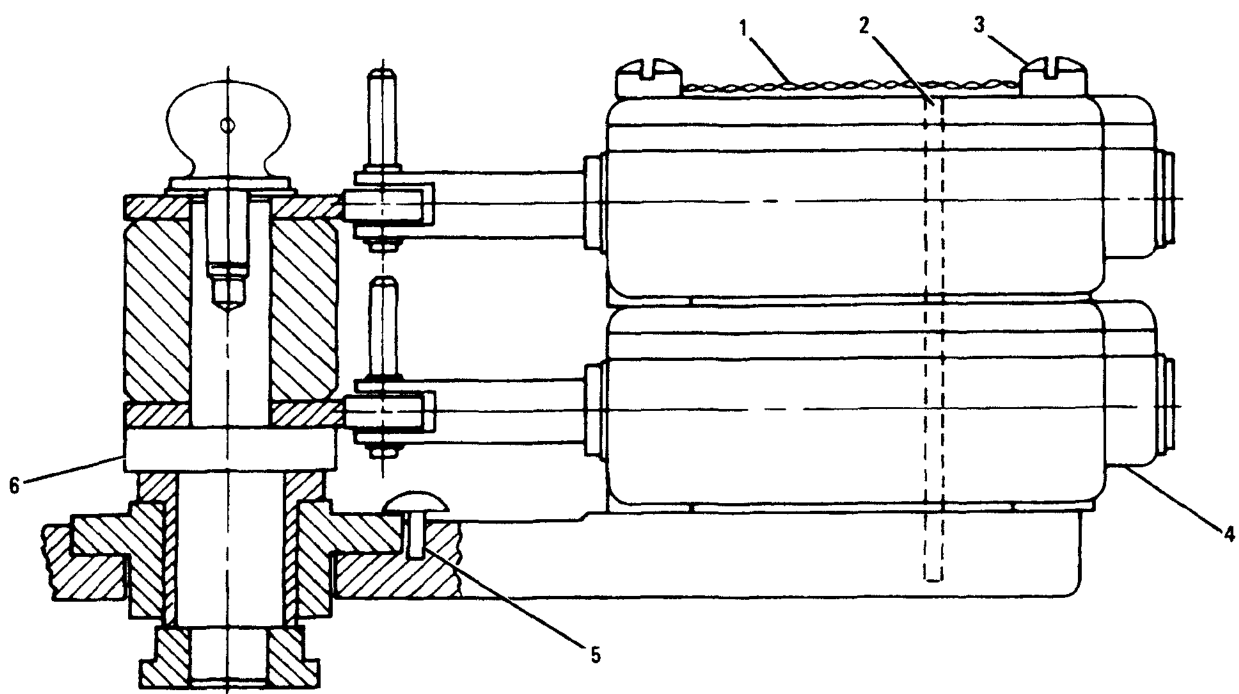
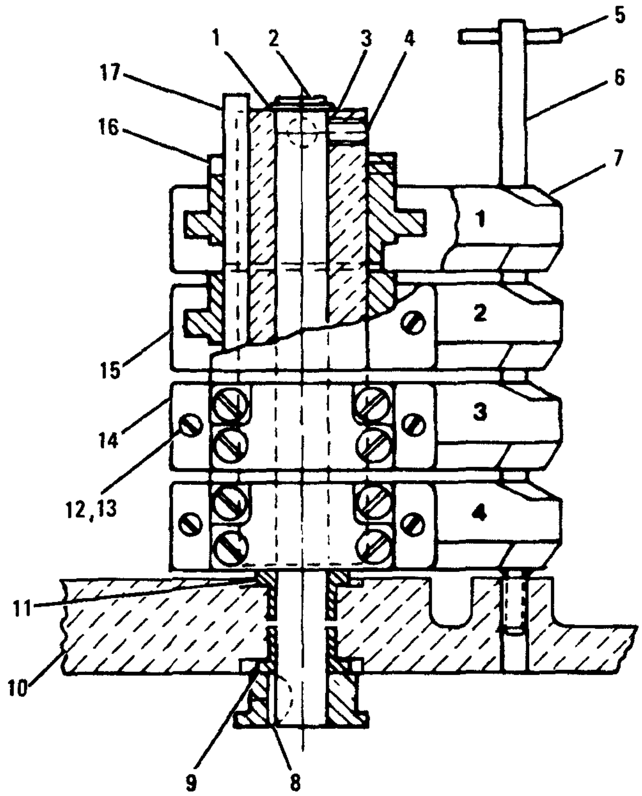


Figure 8. Characterized Feedback Assembly

Item	Description	Stock No.	Qty.
8-	Characterized Feedback . . . . Assy	68D-015436	1
-1	Wire, Tie	COML	AR
-2	Pin, Dowel, 0.093 Dia. x . . . . 0.31" (single)	57A-015176-031	1
	Pin, Dowel, 0.093 Dia. x . . . . 1.38" (tandem)	61A-015525-001	1
-3	Screw, Fil Hd, ... 10-32 x 1-3/8" (single)	COML	2
	Screw, Fil Hd, ... 10-32 x 2-3/8" (tandem)	COML	2
-4	Linear Pot Assy (single)	68C-015435-001	1
	Linear Pot Assy (tandem) . . .	68C-015435-002	1
-5	Screw, Truss Hd, ... 8-32 x 0.25"	54A-015032-025	2
-6	Cam Shaft Assy (single)	68B-015488-001	1
	Cam Shaft Assy (tandem) . . .	68B-015488-002	1

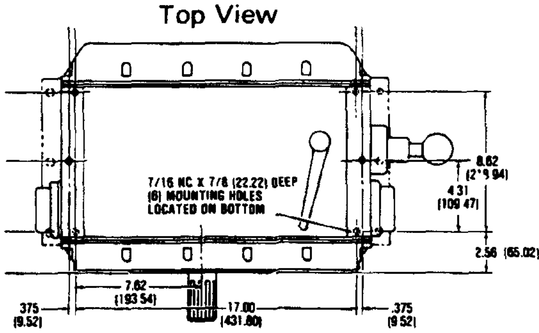
Figure 9. Heavy Duty Feedback Switch Assembly

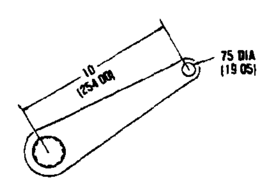


Item	Description	Stock No.	Qty.
9-	Heavy Duty Feedback . . . Switch Assy	68C-014213-1	1
-1	Ring, Retaining. . . . . (Truarc 5100-50)	58B-014183-050	1
-2	Shaft, Inner	62A-014212-001	1
-3	Shaft, Feedback	62A-014211-001	1
-4	Setscrew, Soc Hd, ... 1/4-20 x 0.38"	54A-015067-038	1
-5	Pin, Roll, 1/8 Dia. x 1" . .	57A-015185-100	1
-6	Key, Feedback, Round. . .	61A-014789-001	1
-7	Molding, Feedback Plate. .	61B-014592-001	4
-8	Key, Woodruff (404)	COML	1
-9	Bushing	18B-SP1988-038	1
-10	Support, Center	60D-014064-001	1
-11	Bushing	18B-SP1988-076	1
-12	Screw, Rd Hd, ... 6-32 x 0.50"	54A-015023-050	8
-13	Washer, Lock	56A-015180-002	8
-14	Switch, Limit, AC, ... (Standard)	46A-010017-001	4
	Switch, Limit, DC, ... (Used with Amp)	46A-010017-003	4
-15	Molding, Cam.	14B-012775-001	4
-16	Ring, Retaining. . . . . (Truarc 5103-125)	58B-017287-125	1
-17	Key, Machining. . . . . Feedback	61A-013519-003	1

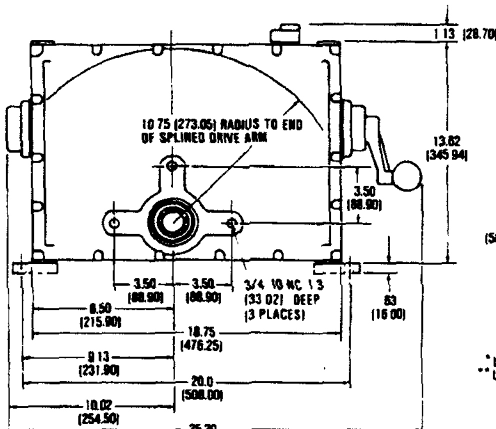
DIMENSIONS

Top View

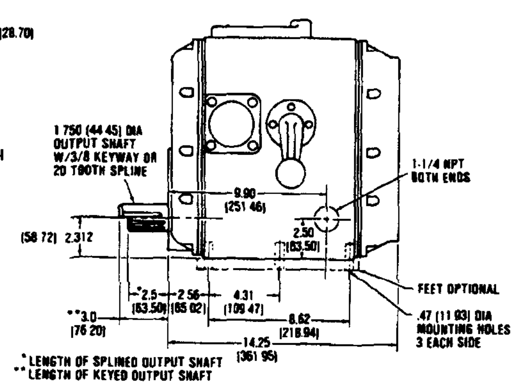




Drive Arm



Side View



End View

Dimensions in parenthesis, ( ) are metric.

IP7_036937

INSTALLATION

MOUNTING

The outline and mounting dimensions for a standard unit are shown on page 9 of this brochure. The rear cover opposite the output shaft must have clearance so that it may swing open for adjustments and interconnect wiring. When the actuator is directly coupled to a drive shaft, it is recommended that a flexible no backlash type coupling be used. The output shaft is also available with a splined output for standard lever arms and linkage drive to the driven load. The unit may be mounted on the standard foot mount, or a flange mount. Mounting may be in any position convenient to the driven load. When mounting the unit, be sure that no excessive axial or side loading is applied to the output shaft. The limit switches and position feedback are connected through gearing to the output shaft of the actuator which should be positively secured to the driven load shaft so that no slippage can occur which would cause misalignment or damage.

When manual override is required, as in the event of a power failure, or to initially align and connect linkages, de-energize the motor before starting the manual cranking procedure. The crank is engaged by operating the auto-manual selector lever at the top of the actuator. Facing the crank end of the actuator, with the output shaft to the left, pull the lever toward you until latching occurs. If latching does not occur, turn the crank handle slowly while continuing to operate the lever. Latching will then occur. Release the lever. It will return to the normal position. Normally crank handle rotation of less than 180° will enable engagement.

Hand cranking will now rotate the actuator output shaft to the desired position. CW rotation of the crank will result in CW rotation of the shaft when viewing the shaft-end side of the actuator. If during manual cranking, electric power were to be applied to the actuator, the handcrank will be instantly disengaged and the actuator will respond to the power command. The manual crank cannot be power driven, thereby protecting the operator.

Care should be taken when manually driving a load, to recognize that excessive output torque can be developed through the handcrank. A mechanical telltale-indicator shaft, located in the center of the thrust housing assembly nearest the handcrank, indicates the over-torquing. The telltale shaft will either protrude or recede depending on the direction of over-torquing. Discontinue cranking in that direction on over-torque warning.

The limit switch and feedback area of the actuator depends upon the cover to maintain the NEMA 4 rating. This cover should be removed only when actual work is being done in that area and reinstalled immediately thereafter.

This actuator contains no internal mechanical stops. If it is allowed to run outside of the initial factory alignment of the limit switches, a realignment of switches and feedback might be required. However, no internal damage will have occurred. Refer to page 11 for limit switch adjustment.

MECHANICAL

Mount the actuator per the provisions shown in the installation drawing.

When coupling to a keyway shaft, attach a load coupling device to the shaft using a 3/8 x 3/8 standard key. When a keyed shaft is specified, care should be taken to orient the coupling that will connect the actuator to the driven load. The output shaft of the actuator rotates only 90° and the keyway when in the straight up position with respect to level orientation, represents the 45° position. If the driven load is a butterfly valve or damper, caution should be taken to insure that the limited range of the actuator matches the limited range of the driven load.

ELECTRICAL INTERCONNECT

The wiring diagrams on page 12 show the interconnect wiring connections for typical three phase control, one phase control and the standard DC motor. These drawings show an arrangement with torque switches, limit switches, feedback potentiometer and a heater. To meet special requirements, certain items shown may not be supplied and in that case the terminals will be blank. In all instances the wiring diagram appropriate to the equipment will be supplied with the equipment.

A barrier type terminal strip is located under the rear cover opposite the output shaft. One conduit entry is located at each end of the unit to accommodate standard 1-1/4 inch N.P.T.

CAUTION: Three phase or DC units must have their limit switches and torque switches wired into their controlling device so as to cause end of travel or torque shut down. Care must be taken in wiring these to the controlling device so that the appropriate direction of drive is turned off when that direction's protective switches are actuated. If care is no taken in properly phasing the equipment, damage may occur to the actuator or the driven load.

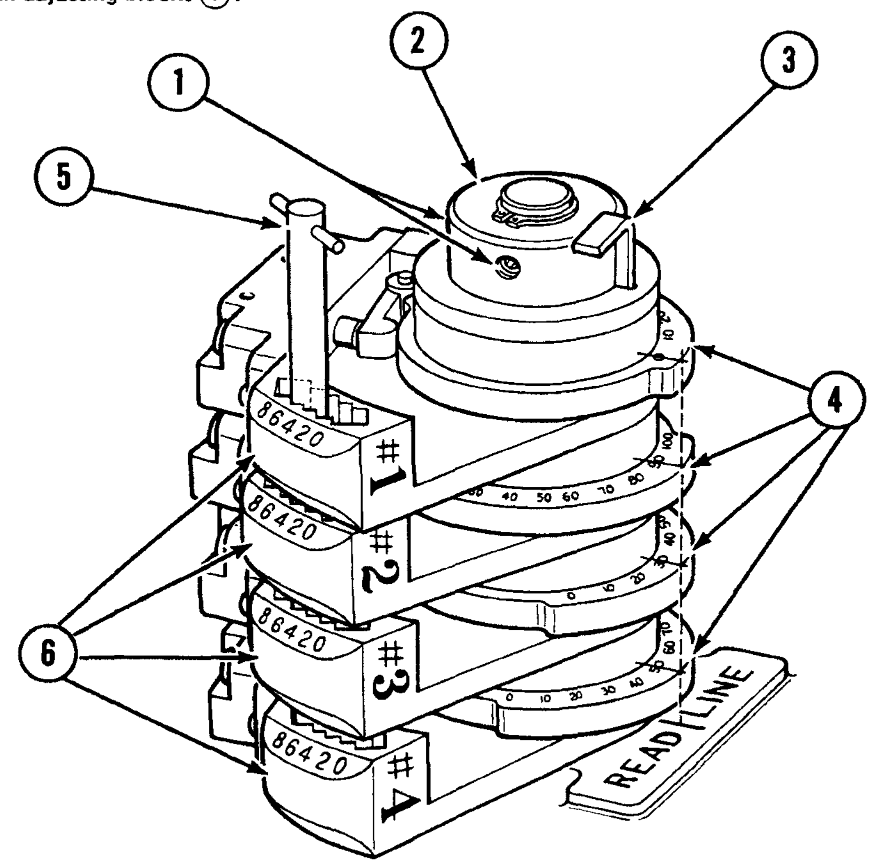
Refer to page 9 for additional electrical information and date.

MAINTENANCE

Under normal service conditions the motor, gearing, bearings and parts are all pre-lubricated and should not require periodic maintenance. If for any reason the unit is disassembled in the field, all oillite bushings should be resaturated with an S.A.E. 30 oil and all gearing heavily coated with an Andok B or equal grease. Care should be taken to insure that no foreign material is allowed to become entrained with the grease in the gear train, which will cause premature failure.

KEY LOCK SWITCH ADJUSTMENT

The key lock limit switch assembly is a method of switch adjustment that after alignment may be adjusted without special tools. Following Steps 1 and 2 are normally factory adjustments. Steps 3 through 9 describe how coarse 10% adjustments are made with cams (4) and fine 2% adjustments are made with adjusting blocks (6).



1. Manually turn the actuator to the full clockwise position, viewing the output shaft.

2. Loosen 2-# ¼-20 set screws (1) in outer shaft (2). Rotate (2) until key (3) lines up with "Read Line". Lock both set screws (1). This is a one time alignment, and the screws must be tight.

3. Pull Key (3) which will release the cams (4). The outer most cam #1 and cam #3 are the clockwise cams. The scale on the cams represent % of travel in increments of 10% with 0 at the clockwise end. Rotate cams 1 and 3 to the nearest 10% increment below the desired CW travel limit. That is if 4% is required, set cam (4) at 0 on the read line.

4. Cam 2 and 4 are the counter clockwise cams. 100% will be at the counter clockwise end. Rotate cams 2 and 4 to the nearest 10% increment below the desired CCW travel limit. That is if 96% is required, set cams at at 90% on the read line.

5. Insert Key (3) to lock cams in place after settings are made. Cams might have to be moved a small amount to line up key with keyway.

6. Unscrew pin (5) until loose and pull completely out of fine adjusting blocks (6).

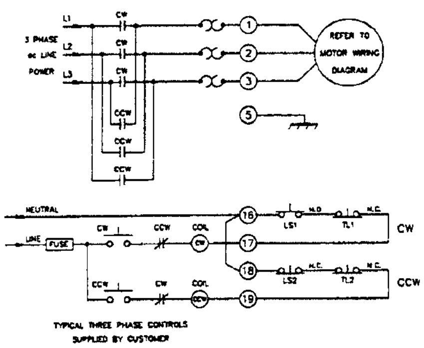
7. The fine adjusting blocks have 5 positions that pin (5) may be placed in. Each position represents a 2% increment within the 10% range on the cam. If 4% is desired at the clockwise end of travel, insert pin (5) in the square hole opposite 4 on the adjusting block (6) on switch 1. Insert pin (5) through the remaining blocks adjusting the desired percentage on each one.

8. As the pin (5) is inserted in the last block, the complete group of blocks should be positioned so that pin (5) may be screwed back in the tapped hole.

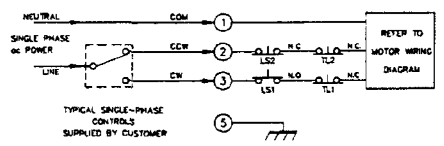
9. Observe the position that the actuator stops at, and if incorrect, note the amount that it is off so that the switches controlling that position may be adjusted that amount. Remember if the shaft requires correction CW move switches to a lower percent of travel. If CCW move switches to a higher setting.

TYPICAL WIRING DIAGRAMS

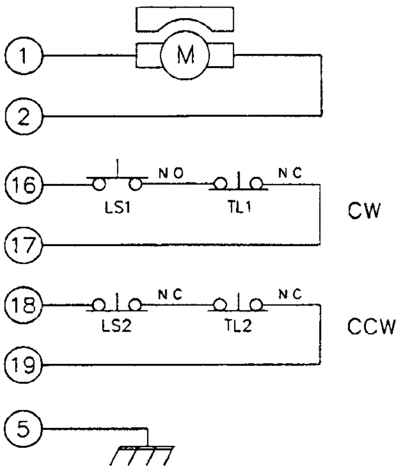
SM-5210



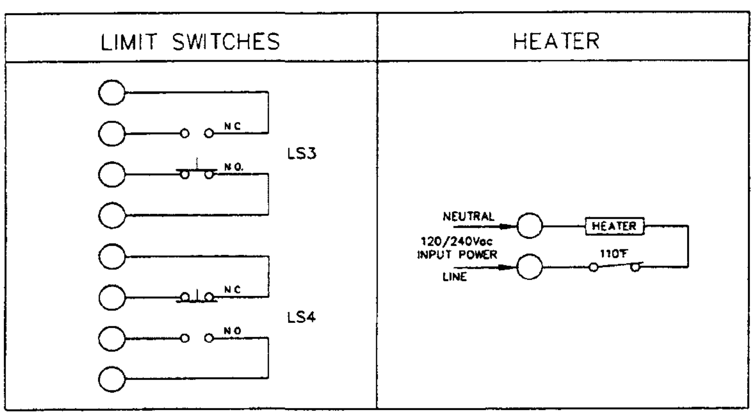
SM-5220



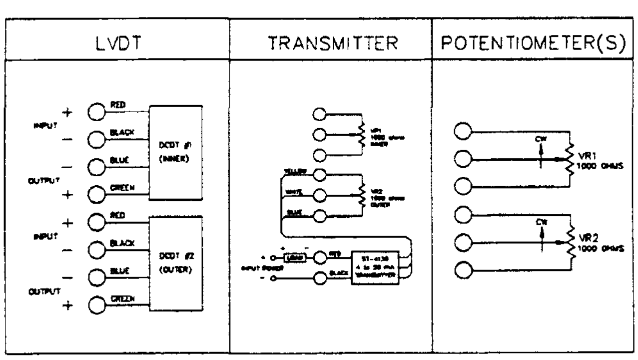
SM-5260



OPTIONS



FEEDBACK DEVICES



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IM-0464 8/93
Supersedes IM-0464 11/80

Jordan Controls, Inc.

Instruction Manual

IM-0607

AD-8100 & AD-8200 Servo Amplifiers

TABLE OF CONTENTS

Due to wide variations in the terminal numbering of actuator products, actual wiring of this device should follow the print supplied with the unit.

GENERAL INFORMATION

INTRODUCTION

Jordan Controls, Inc., designs, manufactures, and tests its products to meet many national and international standards. For these products to operate within their normal specifications, they must be properly installed and maintained. The following instructions must be followed and integrated with your safety program when installing, using, and maintaining Jordan Controls products:

- Read and save all instructions prior to installing, operating, and servicing this product.
- If you do not understand any of the instructions, contact your Jordan Controls representative for clarification.
- Follow all warnings, cautions, and instructions marked on, and supplied with, the product.
- Inform and educate personnel in the proper installation, operation, and maintenance of the product.
- Install equipment as specified in Jordan Controls installation instructions and per applicable local and national codes. Connect all products to the proper electrical sources.
- To ensure proper performance, use qualified personnel to install, operate, update, tune, and maintain the product.
- When replacement parts are required, ensure that the qualified service technician uses replacement parts specified by Jordan Controls. Substitutions may result in fire, electrical shock, other hazards, or improper equipment operation, and will void product warranty.
- Keep all product protective covers in place (except when installing, or when maintenance is being performed by qualified personnel), to prevent electrical shock, personal injury, or damage to the actuator.

WARNING - SHOCK HAZARD

Installation and servicing must be performed only by qualified personnel.

WARNING - ELECTROSTATIC DISCHARGE

This electronic control is static-sensitive. To protect the internal components from damage, never touch the printed circuit cards without using electrostatic discharge (ESD) control procedures.

RECEIVING/INSPECTION

Carefully inspect for shipping damage. Damage to the shipping carton is usually a good indication that it has received rough handling. Report all damage immediately to the freight carrier and Jordan Controls, Inc.

Unpack the product and information packet taking care to save the shipping carton and any packing material should return be necessary. Verify that the items on the packing list or bill of lading agree with your own.

STORAGE

If the product will not be installed immediately, it should be stored in a clean, dry area where the ambient temperature is not less than -20° F, and is a non-corrosive environment.

EQUIPMENT RETURN

A Returned Goods authorization (RG) number is required to return any equipment for repair. This must be obtained from the Jordan Controls Service Department. (Telephone: 414/461-9200) The equipment must be shipped, freight prepaid, to the following address after the RG number is issued:

Jordan Controls, Inc.
5607 West Douglas Avenue
Milwaukee, Wisconsin 53218
Attn: Service Department

To facilitate quick return and handling of your equipment, include:
RG Number on outside of box
Your Company Name, Contact Person, Phone/Fax number
Address
Repair Purchase Order Number
Brief description of the problem

ABBREVIATIONS USED IN THIS MANUAL

AC	Alternating Current
DC	Direct Current
DIP	Dual Inline Package (switch)
Hz	Hertz
LED	Light Emitting Diode
LOS	Loss of Signal
mA	Milliamp
NC	No Connection
RG	Return of Goods
Vac	Volts ac
Vdc	Volts dc

GENERAL DESCRIPTION

The AD-8000 series of servo amplifiers are on/off triac output AC servo amplifiers suitable for operating a variety of Jordan Controls actuators. Standard features include on-board switch selectable command input for 0-5 Vdc, 0-10 Vdc, or 4-20mA; selectable loss of command signal operation; 4-20mA isolated output transmitter tracking actuator shaft position; dynamic motor braking; 120 or 240 Vac, 50/60 Hz. input power depending on actuator motor being used; and on-board LED's and adjustment pots for ease of set-up. The customer's command signal is isolated from both the ac line and the electric motor in the actuator.

In addition, the AD-8230 servo amplifiers features an isolated, null output for customer use. The amplifier will output line voltage AC, or half wave DC, when the actuator is stopped, or when running - selectable by the customer.

BASIC MODELS

AD-8130: For integral installation on all Jordan AC powered 1100, 1700, 2400 and 5100 Series actuators

AD-8130/EC-10835: For direct replacement of AD-8850 and AD-8860

AD-8230: For integral installation on all Jordan AC powered 1500, 1600 and 3330 Series actuators

AD-8230/EC-10836: For new installations requiring remote servo amplifier installation or for direct replacement of existing AD-8813, AD-8823, AD-8833 and AD-8843 series amplifiers. Also used as an integral amplifier with Jordan SM-5220 actuator.

AD-8230/EC-10842: For replacement of all AD-8210 and AD-8220 Series amplifiers. (Same as AD-8230, except with a wire harness and molex connectors)

SPECIFICATIONS

POWER:
Voltage Input: 120 or 240 Vac, 50 or 60 Hz, single phase
(Voltage input <u>must</u> match actuator motor voltage rating)
Power Consumption: less than 20 watts for amplifier functions only
Voltage Output: identical to voltage input
Current output: 10 amps maximum at 120 or 240 Vac
Fuse protection: customer supplied. Size based on actuator controlled, and local codes
Null output (AD-8230): rated 2 amperes @ 120 or 240 Vac, 50 or 60 Hz

COMMAND SIGNAL INPUTS, FIELD SELECTABLE:
4-20mA current command into a 200 ohm impedance
0 to 5 or 0 to10 vdc voltage command into a 100,000 ohm impedance
1000 ohm potentiometer command is an option on the AD-8230/EC-10836 model only

POSITION FEEDBACK SIGNAL:
1000 ohm potentiometer
4 to 20mA (optional on AD-8230/EC-10836 models only)

POSITION SIGNAL OUTPUT: Isolated, 2 wire, 4 to 20mA signal

APPROXIMATE WEIGHTS:
AD-8130, AD-8230 & AD-8230/EC-10842 - 2 lbs. (0.9 kg)
AD-8130/EC-10835 & AD-8230/EC-10836 - 4 lbs. (2 kg)
with enclosure E - 25 lbs. (11 kg)
with enclosure X - 40 lbs. (18 kg)

INSTALLATION WIRING

Most installations locate the servo amplifier inside a Jordan actuator, for ease of mounting and to protect the amplifier. This is the preferred mounting arrangement. For remote mounting, the servo amplifier and actuator should be as close to each other as possible.

Ensure all connections are correct and tight before applying power. Power, command signal, feedback signal, and motor output are the minimum required connections. To connect optional features for electromagnetic brake control or optional indicator lights, refer to the wiring diagram for the specific amplifier and actuator.

- All wiring should be done in accordance with prevailing codes by qualified personnel.
- Typical wiring diagrams are shown on pages 8 thru 12.
  Actual wiring should follow the print supplied with the actuator.
- Fusing must be installed in line power, and should be of the slow blow type.
- After installation, it is recommended that all conduits be sealed to prevent water damage.
- All low level signal wiring should be a shielded type with the shield grounded at source common.

SET-UP & CALIBRATION

When placing the amplifier and actuator into service, the amplifier must be calibrated for the application. The servo amplifier is supplied factory calibrated when ordered with a Jordan Actuator and should require only minor adjustment.

Read and follow the instructions carefully before attempting to make adjustments to the servo amplifier.

1. First, be sure that the line power to the actuator matches the actuator nameplate. Improper input voltage will cause the actuator to misperform. The amplifier voltage selector switch must be in the correct position for the motor voltage being used. Refer to the actuator nameplate for correct voltage to apply. **Operating voltage changes cannot be made simply by changing the position of the amplifier voltage switch.**

2. Check connections. POWER SHOULD BE OFF. Check that the amplifier is properly mounted, that all connections to the actuator are in accordance with the correct Jordan Controls wiring diagram, and that the unit is properly grounded in accordance with all prevailing Electric Codes. Incorrect wiring may cause permanent damage to the servo amplifier and actuator. Verify that the command signal is connected to the proper terminals. Using a voltmeter, confirm that the command signal is present and properly polarized.

   Dynamic braking is standard on this amplifier and, when used, reduces coasting and improves positioning accuracy by applying a braking action to the motor during stopping. Dynamic braking must be selected on or off prior to making any amplifier adjustments. The dynamic brake functions by energizing both motor windings for a fraction of a second. Select either on or off using the appropriate DIP switches.

3. Verify DIP switch settings. Refer to the DIP switch location and table on pages 5 and 6 for the specific amplifier being adjusted. Confirm that the switches are properly set for the intended application. For special applications not listed, consult factory. Incorrect DIP SWITCH settings will prevent proper operation. Check position of the null output jumper P1 and verify that it is in the correct position.

4. NOW APPLY POWER.

5. Set **HI TRIM** and **LO TRIM**. Apply command signal at minimum input value. For 4-20mA systems this would normally be 4mA. Adjust pot labeled **LO TRIM** to move actuator position to correspond with minimum desired position without actuating the end-of-travel limit switch. Next apply command signal at maximum input value. For 4-20mA systems this would normally be 20mA. Adjust pot labeled **HI TRIM** to move actuator position to correspond with maximum desired position without actuating the end-of-travel limit switch. Some interaction of the above pot settings will require repeating this procedure until proper accuracy is achieved.

6. Set **DEADBAND**. Deadband prevents unstable operation, or hunting . The deadband pot is torque sealed at the factory at 0.1% of the control signal span, and this setting will normally be satisfactory. Should the deadband need to be increased, counterclockwise rotation of the **DEADBAND** pot will increase the deadband, preventing hunting . Clockwise rotation of the pot will decrease the deadband. **The correct setting is the point where <u>no</u> hunting is observed AND when both the green and yellow LED's go out when the actuator stops.**

   CAUTION: The deadband must NEVER be adjusted to allow both the yellow and green LED's to be on at the same time. This will result in dangerous overheating and burnout.

7. Loss of signal. In the event of a loss of command signal (LOS), the servo amplifier can be programmed to either lock in place or go to a customer adjusted preset position. Loss of signal feature is only available when using 4-20mA command signal. This feature is normally factory supplied in the lock-in-place selection. A signal level below 3mA results in a loss of signal detection by the servo-amplifier. Refer to the DIP SWITCH chart on pages 5 and 6 to select desired operation. Then, with the servo amplifier in normal operation, apply a command signal below the minimum 3 mA position. If lock-in-place is selected the actuator should stop and the red LOS LED should light. If move to preset is selected, rotate the LOS pot until the actuator moves to the desired position and stops. Reapply and then remove the command signal several times to verify correct operation.

8. Loop powered 4-20mA transmitter. This amplifier is equipped with an on-board two wire transmitter that transmits the true actuator output shaft position and requires an external 12 to 36 Vdc power supply. Adjustment is as follows: Apply a command signal to the actuator at the minimum value. For 4-20mA systems this would normally be 4mA. After the actuator moves to position and stops, adjust the pot labeled **4mA** until the indicator displays 4mA. Then apply a 20mA command signal and wait for the actuator to move and stop. Then adjust the pot labeled **20mA** until the indicator displays 20mA. Repeat this procedure until the desired accuracy is achieved.

9. Switched null output:The AD-8230 is equipped with a TRIAC that will switch line voltage to a customer available connection. This feature may be used to operate a brake in the actuator or to light remote indicating lights. If used for an internal electromagnetic brake, proper adjustment and set-up was performed at the factory. For remote indicating lights, this feature can be configured for either AC or DC output, and to be ON when either the motor is running or when it is idle. A jumper on the printed circuit board indicates the output as AC or DC. Refer to the DIP SWITCH chart to select the output as either ON when the actuator is running, or ON when it is idle.

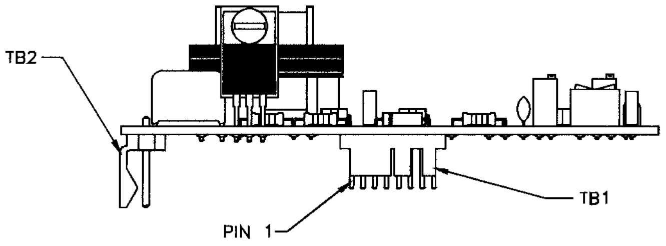
AD-8130
SET-UP AND CALIBRATION

SW2 DIP SWITCH TABLE

SWITCH	POSITION	FUNCTION
1	ON	0-5 VDC OR 4-20mA COMMAND INPUT
	OFF	0-10 VDC VOLTAGE COMMAND INPUT
2	ON	0-10 VDC OR 4-20mA COMMAND INPUT
	OFF	0-5 VDC VOLTAGE COMMAND INPUT
3	ON	LOSS OF SIGNAL - OFF
	OFF	LOSS OF SIGNAL - ON
4	ON	MOVE TO PRESET POSITION ON LOSS OF SIGNAL
	OFF	DO NOT MOVE TO PRESET ON LOSS OF SIGNAL
5	ON	LOCK IN PLACE ON LOSS OF SIGNAL
	OFF	DO NOT LOCK IN PLACE ON LOSS OF SIGNAL
6	ON	DYNAMIC BRAKE ON
	OFF	DYNAMIC BRAKE OFF
7	ON	0-5 OR 0-10 VOLTAGE COMMAND INPUT
	OFF	4-20mA COMMAND INPUT

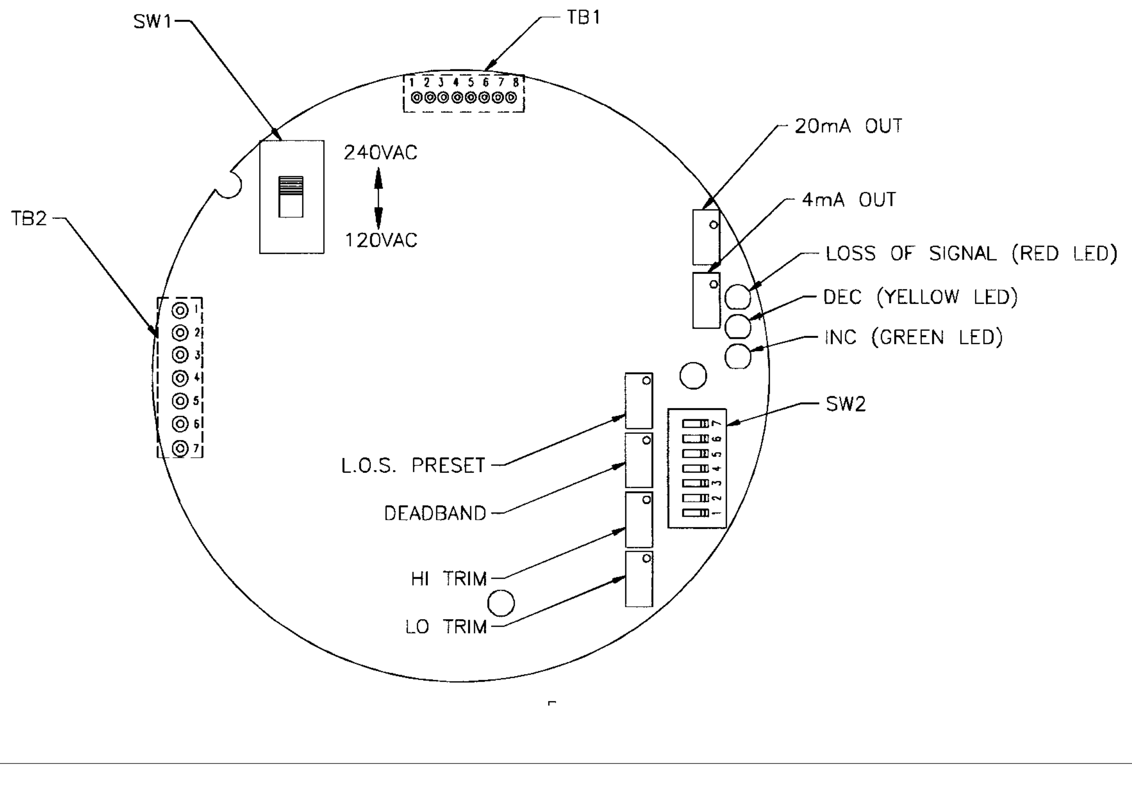
NOTE: When using loss of signal, if DIP switches 4 and 5 are in their on position, the loss of signal action will be lock in place.

COMPONENT SIDE



NOTE: When retrofitting the AD-8130 to replace models AD-8110 or AD-8120, note that the actuator mating connector for TB1 is a 6 pin connector that should engage pins 1 through 6 only. Pins 7 and 8 are 4-20mA outputs for new installations and are not used for replacements. (Note location of pin 1 on above drawing; pins are numbered left to right.) Contact factory if your connectors are located on the component side of the board.

COMPONENT LOCATION
(Looking at component side of board)



AD-8230
SET-UP AND CALIBRATION

SW1 DIP SWITCH TABLE

SWITCH	POSITION	FUNCTION
1	ON	0-5 VDC OR 4-20mA COMMAND INPUT
	OFF	0-10 VDC VOLTAGE COMMAND INPUT
2	ON	0-10 VDC OR 4-20mA COMMAND INPUT
	OFF	0-5 VDC VOLTAGE COMMAND INPUT
3	ON	LOSS OF SIGNAL - OFF
	OFF	LOSS OF SIGNAL - ON
4	ON	MOVE TO PRESET ON LOSS OF SIGNAL
	OFF	DO NOT MOVE TO PRESET ON LOSS OF SIGNAL
5	ON	LOCK IN PLACE ON LOSS OF SIGNAL
	OFF	DO NOT LOCK IN PLACE ON LOSS OF SIGNAL
6	ON	DYNAMIC BRAKE ON
	OFF	DYNAMIC BRAKE OFF
7	ON	0-5 OR 0-10 VOLTAGE COMMAND INPUT
	OFF	4-20mA COMMAND INPUT
8	ON	NULL OUTPUT IS ON WHEN MOTOR IS RUNNING
	OFF*	NULL OUTPUT IS ON WHEN MOTOR IS IDLE
9	ON*	NULL OUTPUT IS ON WHEN MOTOR IS IDLE
	OFF	NULL OUTPUT IS ON WHEN MOTOR IS RUNNING

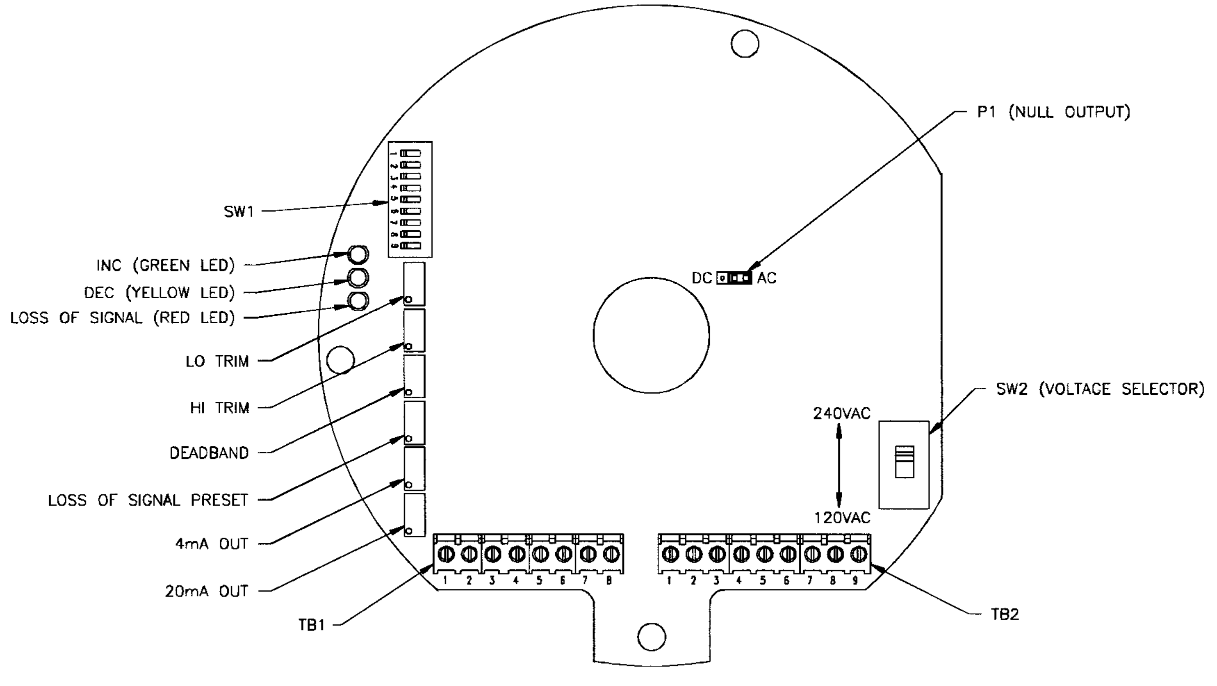
*Must be in these positions when used with 3330 model actuators.

ON-BOARD JUMPER SETTING CONTROLS NULL OUTPUT ONLY

JUMPER POSITION	NULL OUTPUT RESULT
AC*	LINE VOLTAGE
DC	HALF WAVE dc

*Must be in ac position when used with 3330 model series actuator equipped with EC-10678 Brake Module.

COMPONENT LOCATION
(Looking at component side of board)

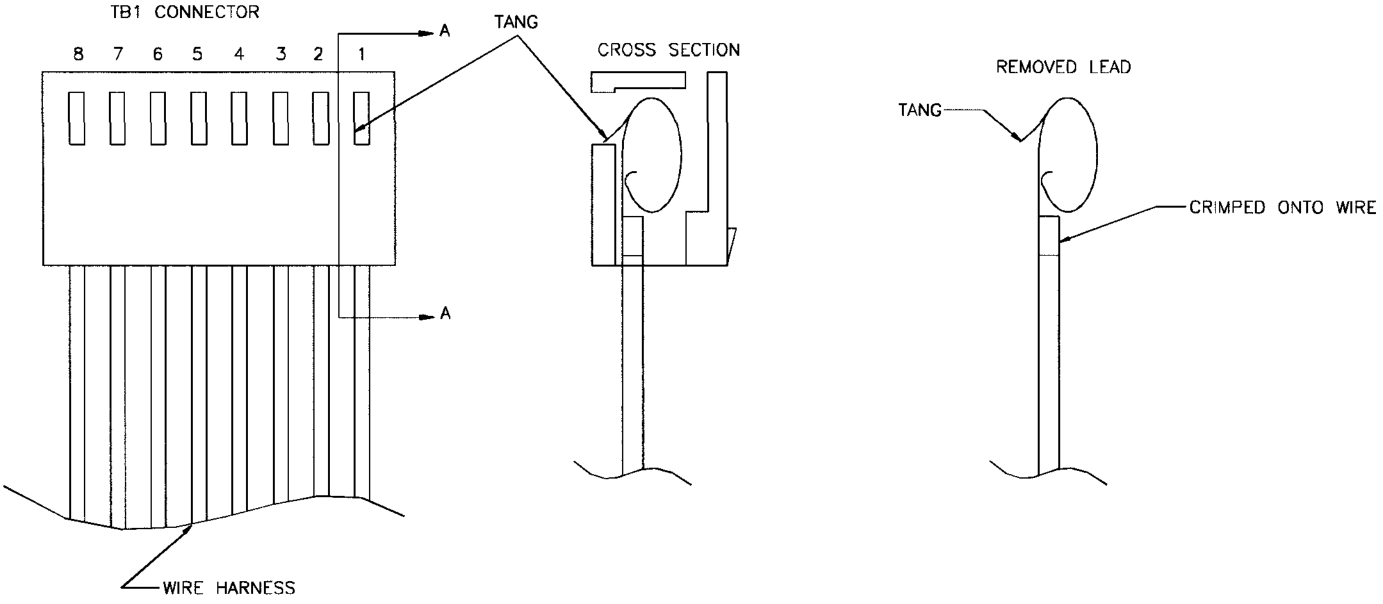


IP7_036946

TROUBLESHOOTING GUIDE

TROUBLE	POSSIBLE CAUSE	REMEDY
1. Motor does not operate	a) No power to amplifier b) Amplifier is in Loss-of-Signal (LED3 is on) c) Amplifier deadband is too wide d) Actuator is wired incorrectly e) Amplifier is defective	a) Restore power b) Check command signal c) Reduce deadband setting d) Correct per wiring diagram e) Replace with new amplifier
2. Motor moves in only one direction	a) Motor and feedback potentiometer are out of phase or no control b) Amplifier is defective	a) For AD-8130, reverse potentiometer leads at TB1-4 & 6 molex connector (see illustration below); for AD-8230 reverse potentiometer leads at TB1-4 & 6 terminal strip b) Replace with new amplifier
3. LED s stay on around null or at null	a) Deadband is too narrow b) Command signal is too noisy	a) Increase deadband settings b) Shield command signal wires

AD-8130 MOLEX CONNECTOR
(Shown larger than actual)

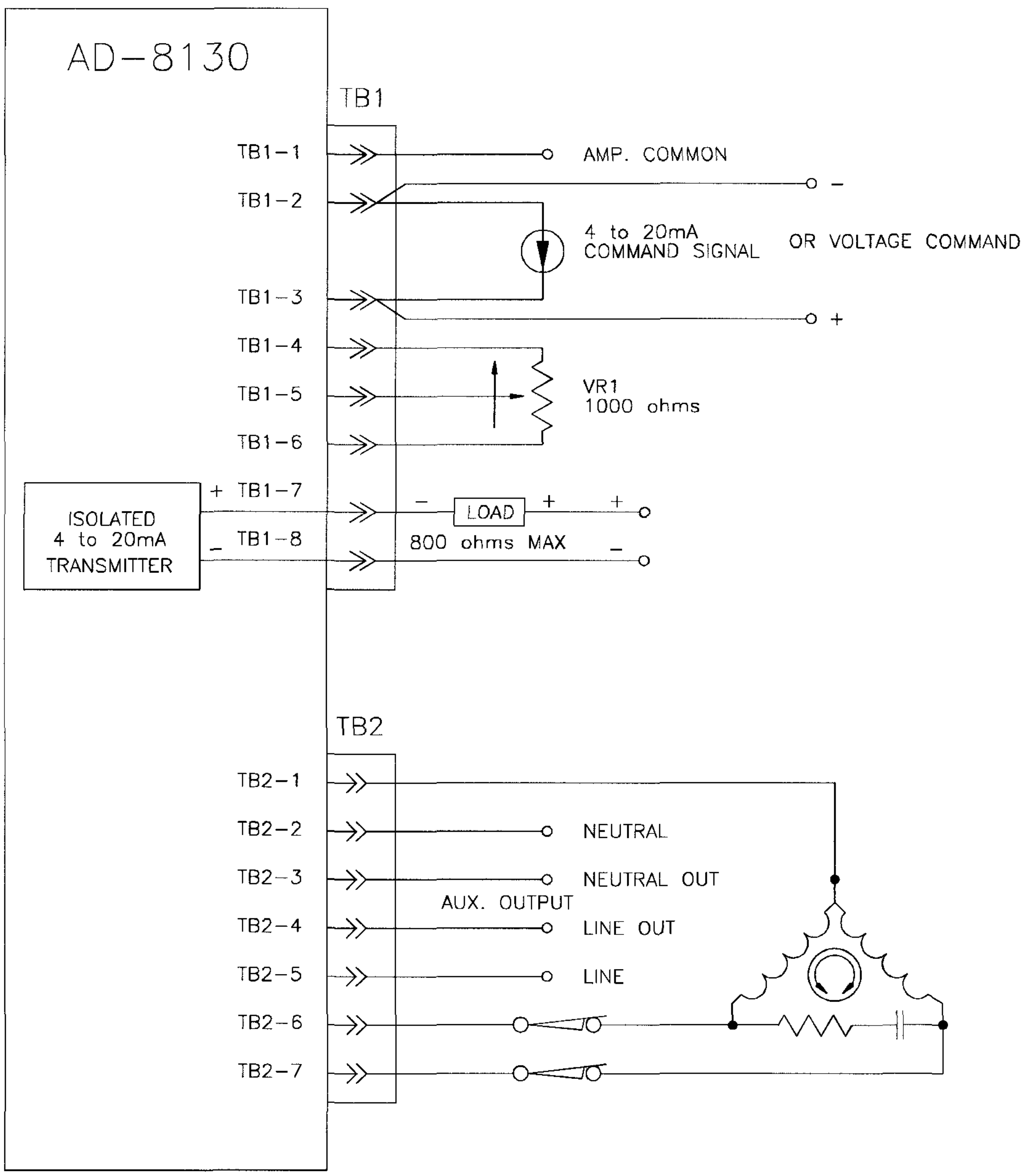


Procedure to change leads in molex connectors (AD-8130 only).

1. With a small screwdriver, depress tang in the small rectangular opening on the connector, and gently remove wires corresponding to pins 4 and 6. Note wire colors so they can be reversed in step 3.
2. Gently bend the tangs outward with a small screwdriver or knife blade to ensure they will lock tightly when reinserted into the connector block.
3. Reverse lead wire color from original location and reinsert back into the connector block.

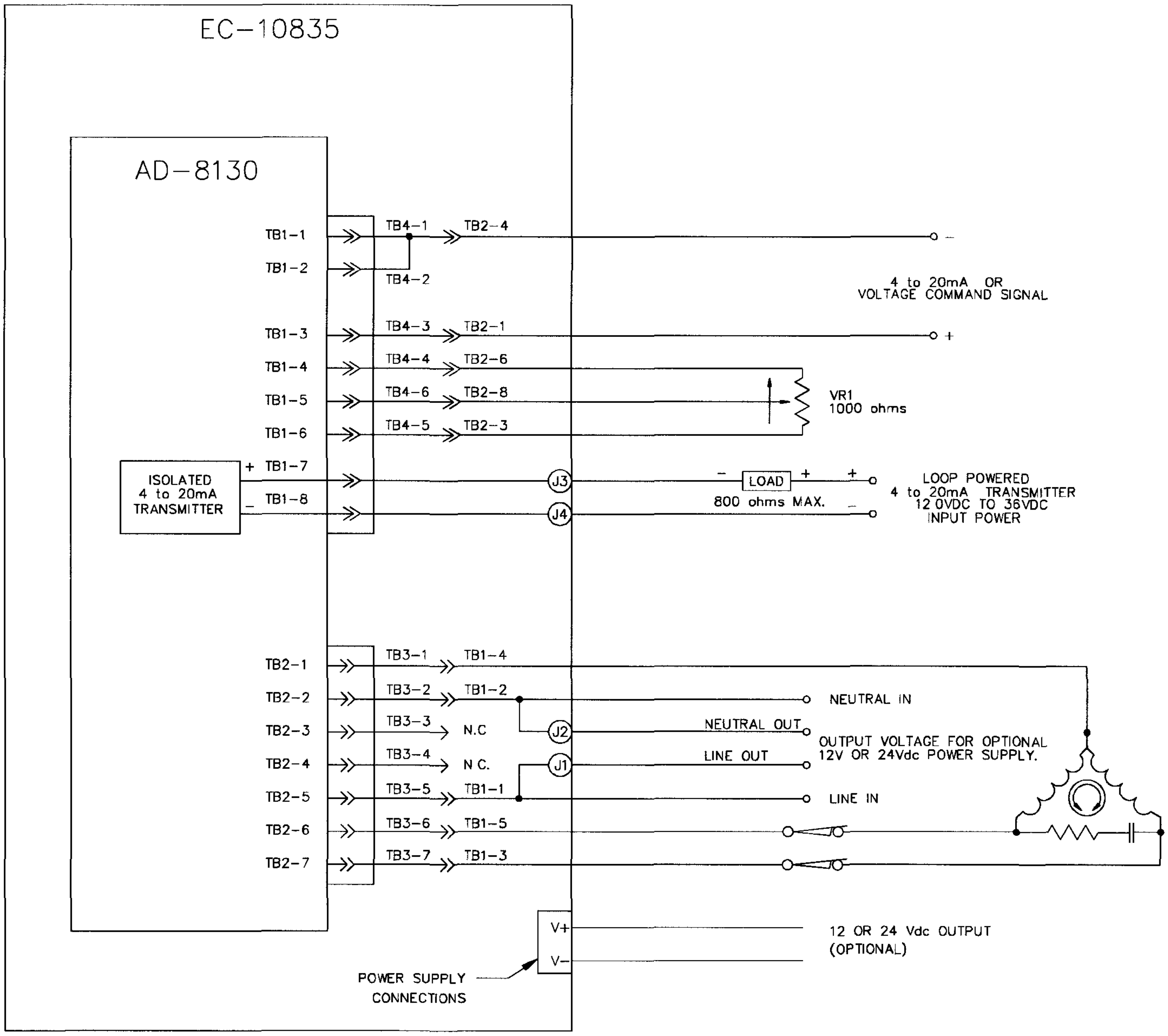
TYPICAL WIRING DIAGRAMS

AD-8130 INTERCONNECT WIRING



TYPICAL WIRING DIAGRAM

AD-8130/EC-10835 INTERCONNECT WIRING
(REPLACEMENT FOR AD-8850 AND AD-8860)

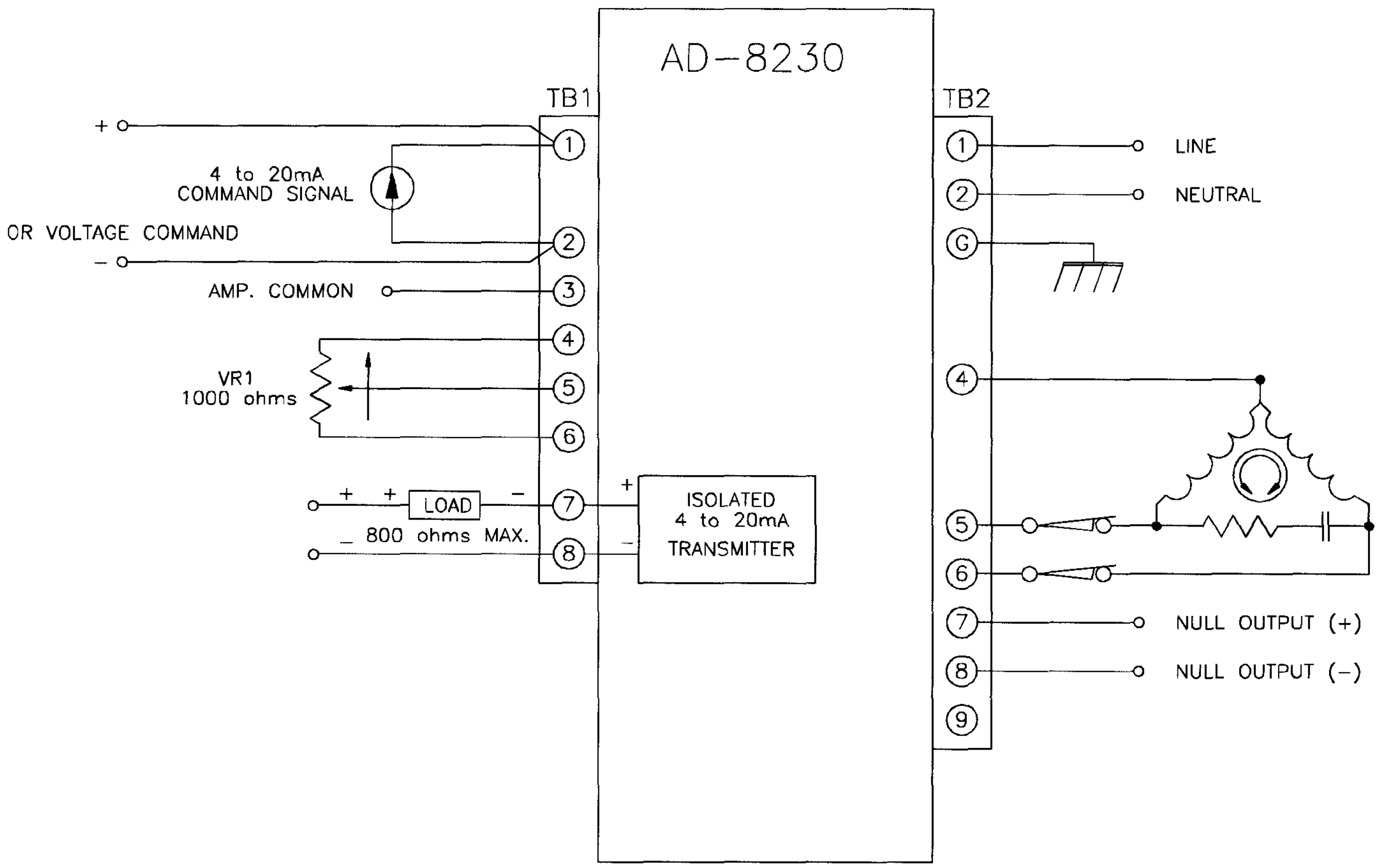


N.C. = NO CONNECTION

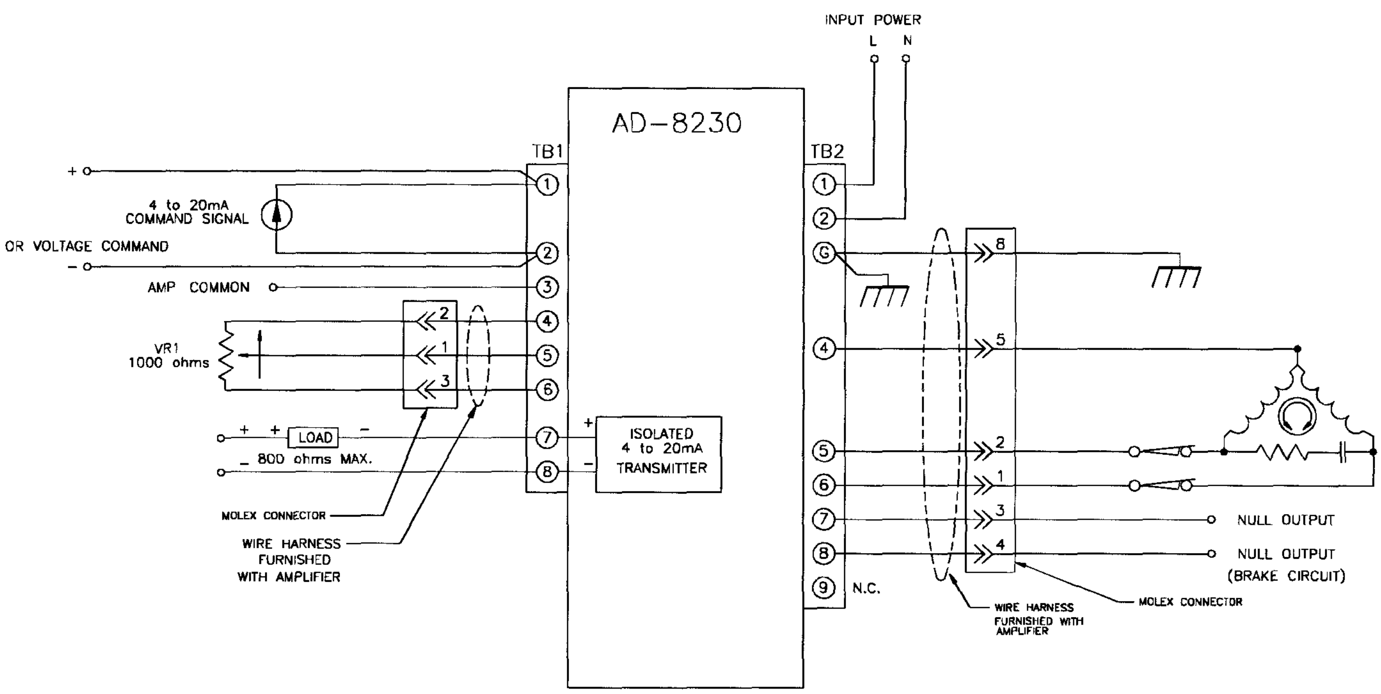
IP7_036949

TYPICAL WIRING DIAGRAM

AD-8230 INTERCONNECT WIRING



TYPICAL WIRING DIAGRAM
AD-8230/EC-10842
(REPLACEMENT FOR AD-8210, AD-8220 AND AD-8210-1001)



NOTE: When replacing AD-8210 or AD-8220 with this amplifier, remove and relocate field wiring as follows:

AD-8210/AD-8220 TERMINAL	AD-8230 TERMINAL
1*	Move to TB1-8
3*	Move to TB1-7
4	Move to TB1-2
5	Move to TB1-1
6	None**
7	Move to TB2-3
8	Move to TB2-2
9	Move to TB2-1

*These terminals will only have field wiring when 4 to 20mA position feedback signal transmitter (ST-4130) is used.

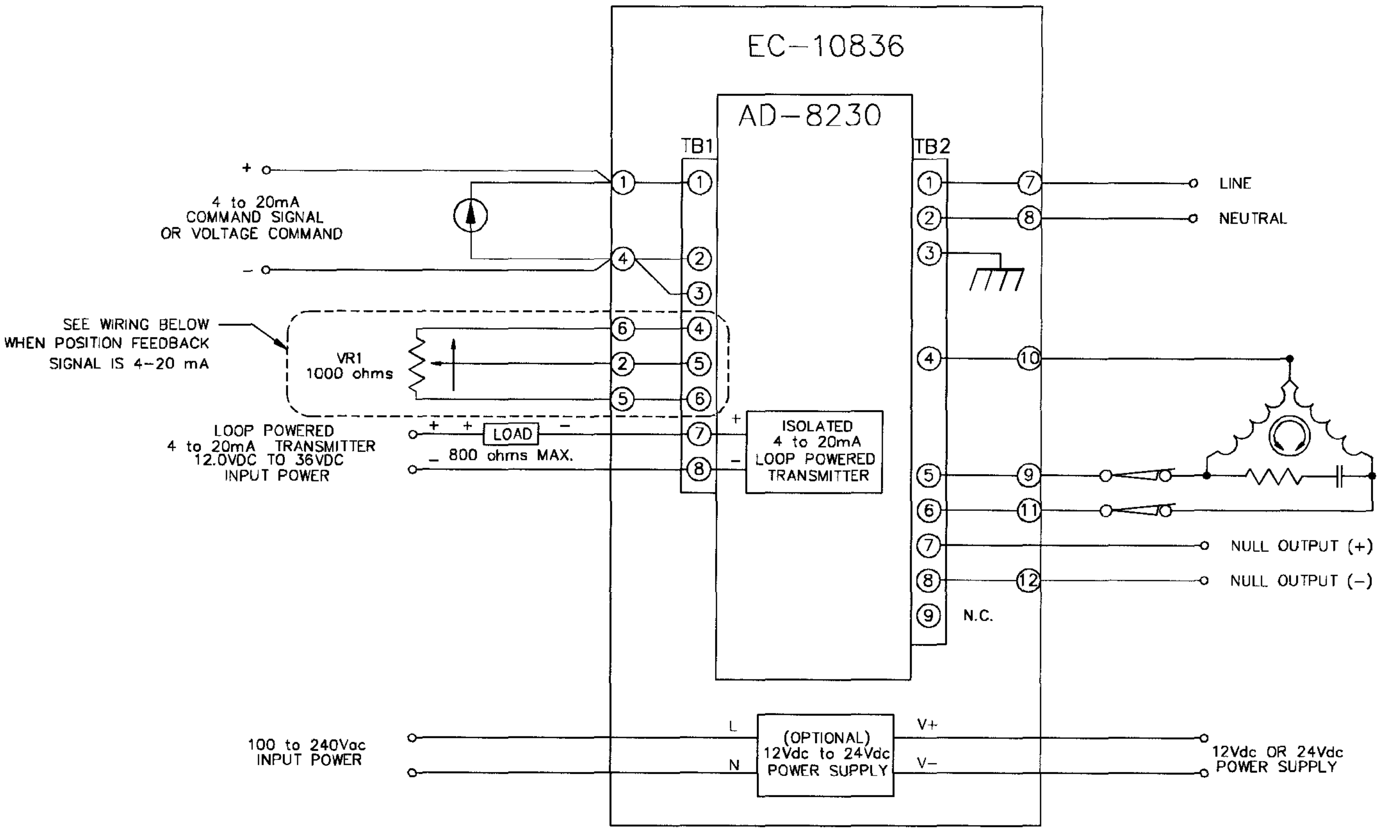
**Command signal ground shield should be grounded at source common and left floating at AD-8230.

TYPICAL WIRING DIAGRAMS

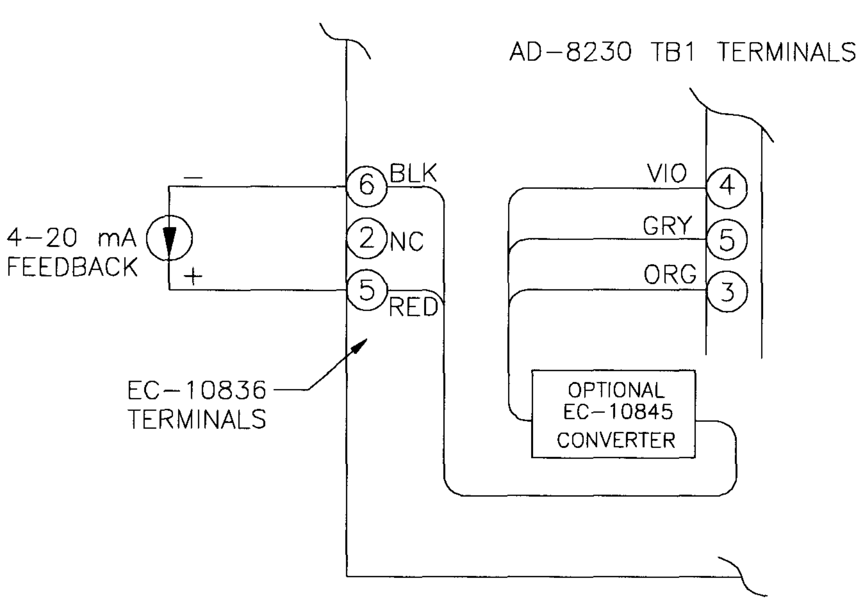
AD-8230/EC-10836

(REPLACEMENT FOR AD-8813, AD-8823, AD-8833 AND AD-8843)

(Also used as an integral amplifier in Jordan model SM-5220 actuators)

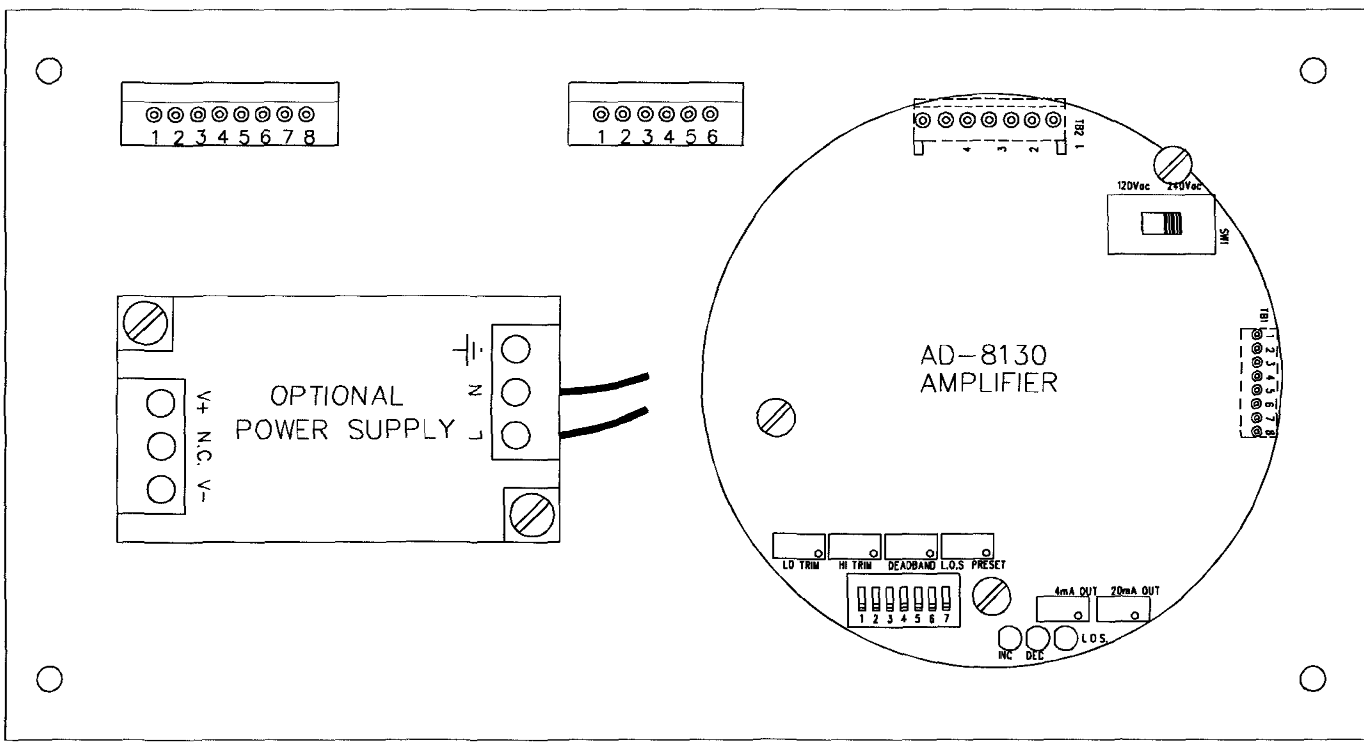


4 to 20mA POSITION FEEDBACK SIGNAL



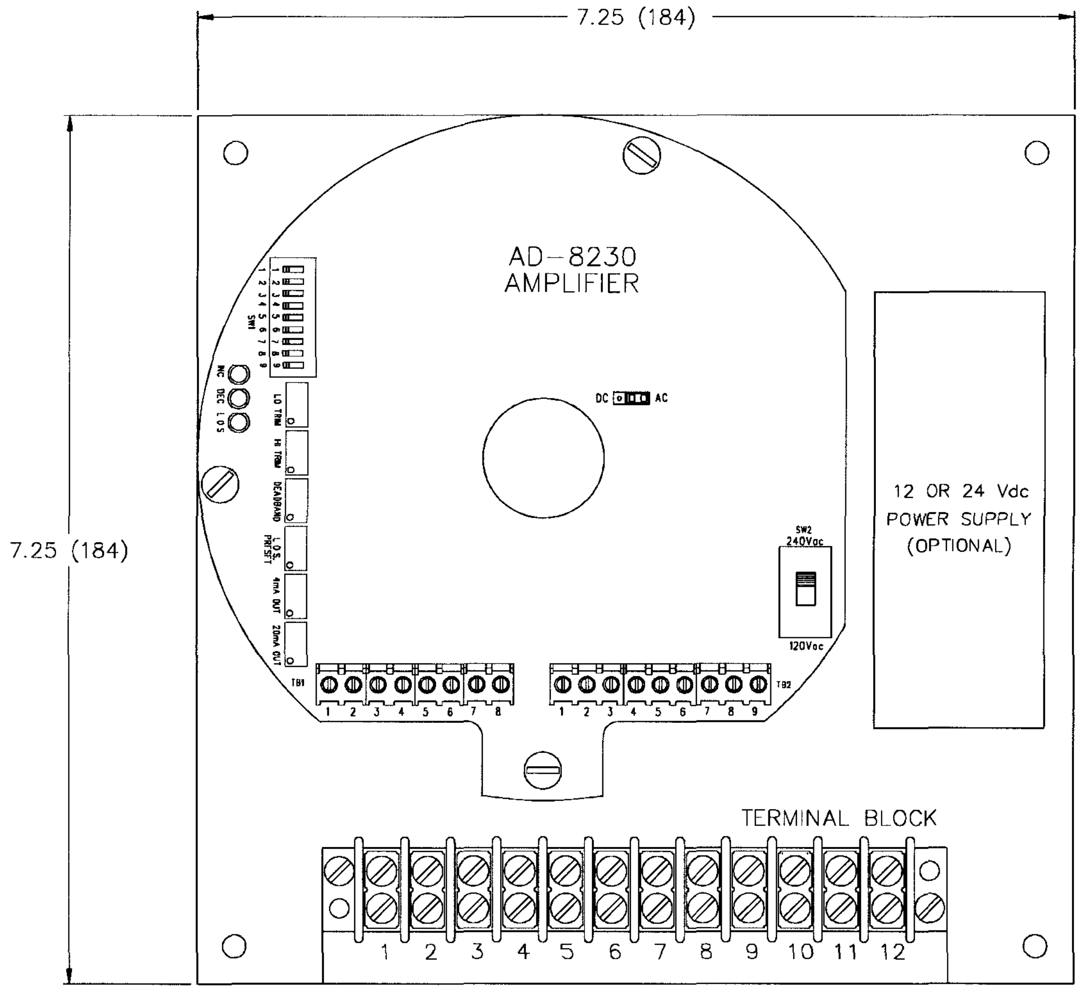
NOTE: The above diagram illustrates 4 to 20mA position feedback signal with customer supplied loop power. An optional 24 Vdc loop power supply is also available from Jordan. Refer to the wiring diagram furnished with the actuator for special calibration instructions when 4 to 20mA feedback is furnished.

AD-8130/EC-10835 PHYSICAL LAYOUT



IP7_036953

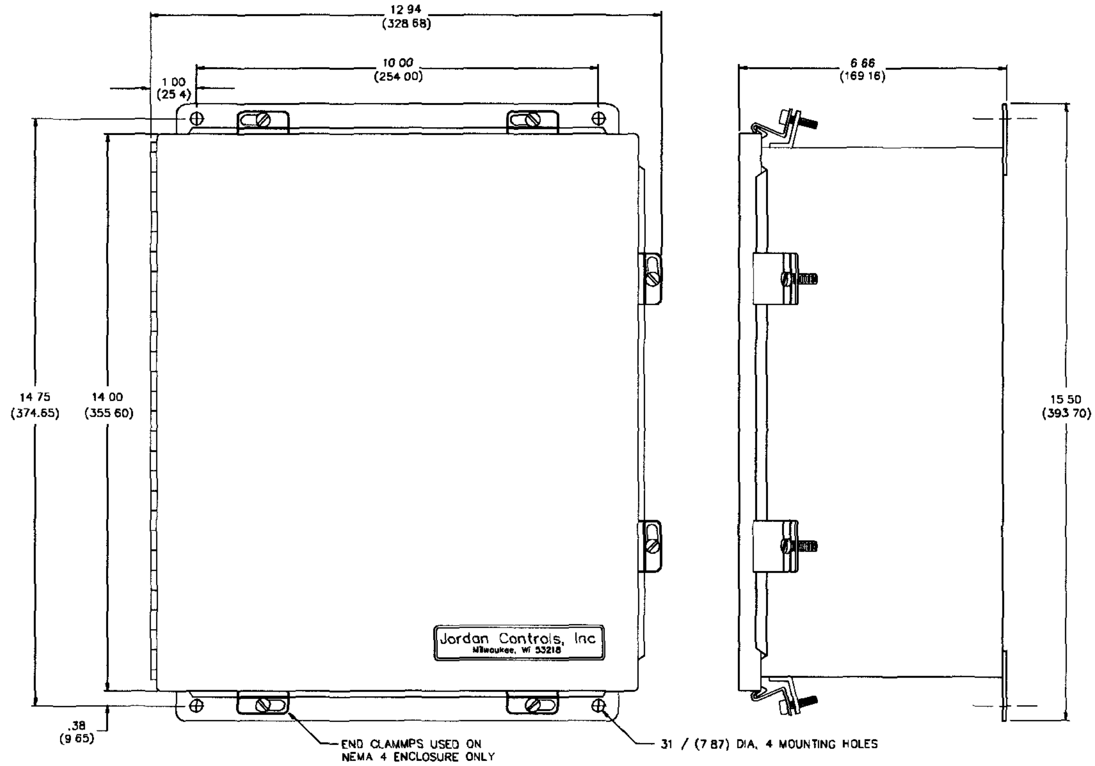
AD-8230/EC-10836 PHYSICAL LAYOUT



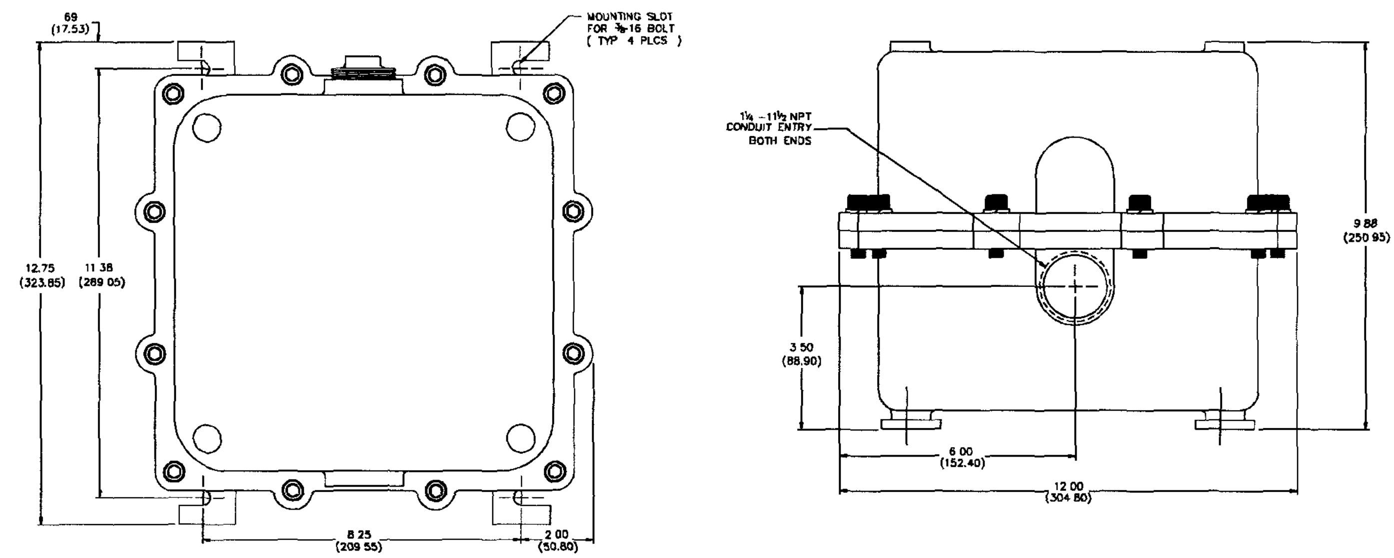
DIMENSIONS = INCHES (MILLIMETERS)

MAJOR DIMENSIONS
AD-8230/EC-10836 INSTALLED IN REMOTE ENCLOSURE

NEMA 4



NEMA 7 & 9



JORDAN CONTROLS, INC.
5607 West Douglas Avenue
Milwaukee, Wisconsin 53218
Phone: (414) 461-9200
FAX: (414) 461-1024
E-Mail: jordan@jordancontrols.com

IM-0607 6/97

These dimensions are subject to change without notice and should not be used for preparation of drawings or fabrication of installation mounting. Current installation dimension drawings are available upon request.

From: <fpalacios@bbpwr.com>
To: <KENNETH-N@ipsc.com>
Date: 2/6/03 2:05PM
Subject: Drawings for BBP PO# 433413 Intermountain Power

Ken:
Here is the set of drawings that Jordan sent to me and that I referred to in my e-mail response to you.
----- Forwarded by Francisco Palacios/Riley/US on 02/06/2003 03:53 PM -----

"Gregory Stark"
<GStark@Jordancontrols.com>
02/05/2003 10:18 AM

To: <fpalacios@bbpwr.com>
cc:
Subject: Drawings for BBP PO# 433413

From: Greg Stark, Applications Engineer, Jordan Controls Inc
Sent: Wednesday, February 05, 2003
To: Babcock Borsig Power Francisco Palacios (fpalacios@bbpwr.com)
Subject: Drawings for BBP PO # 433413

Francisco:

Attached please find the drawings for BBP PO # 433413.

Hard copies will be sent via UPS.

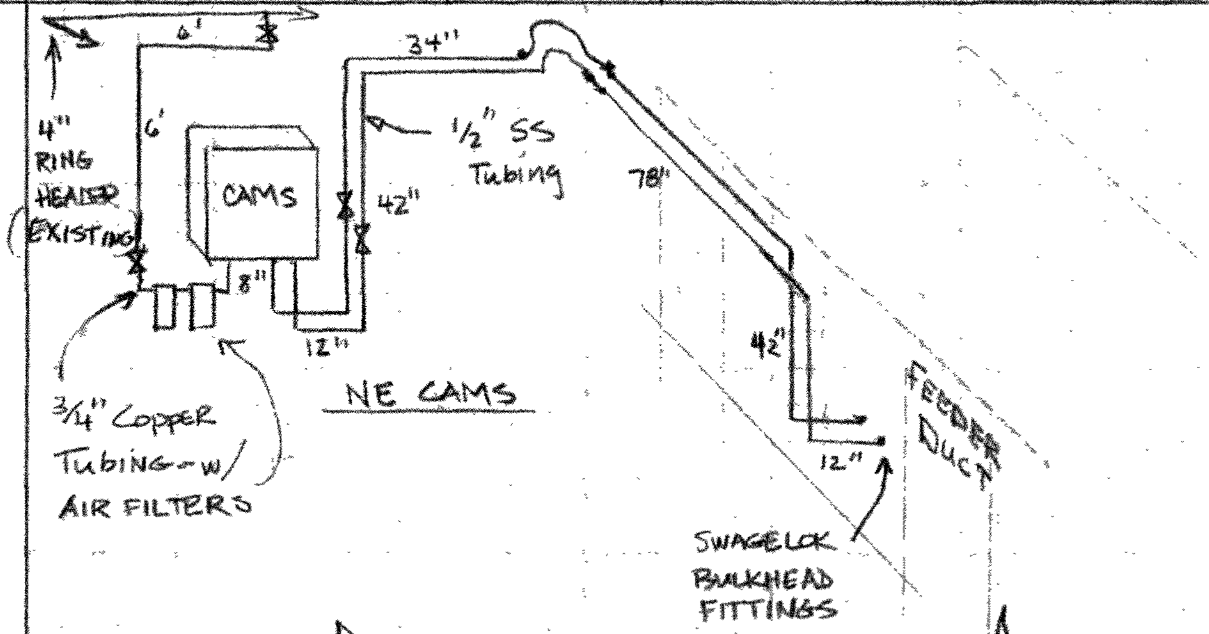
Please feel free to call with any questions or if you require additional assistance.

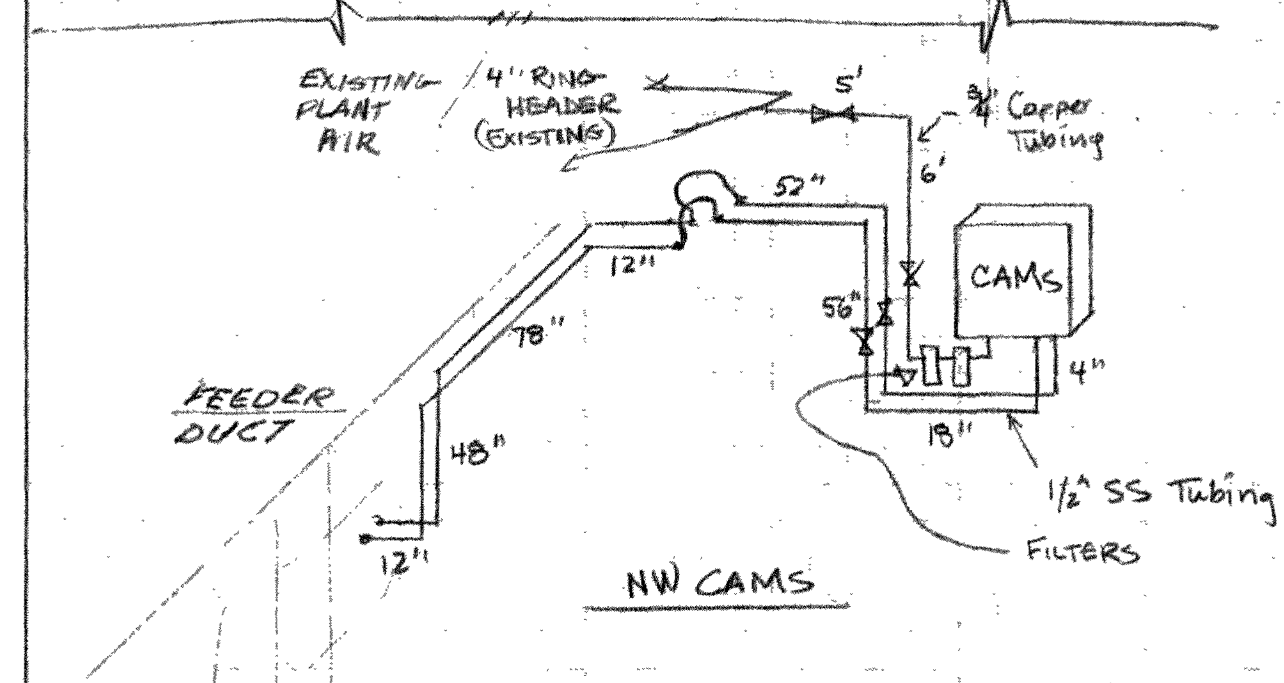
Regards, Greg Stark

(See attached file: D038915.dwg)(See attached file: C027636.DWG)(See attached file: IM-0422.pdf)(See attached file: C03207903.dwg)(See attached file: C028662.DWG)(See attached file: C032073.DWG)(See attached file: A029188.DWG)(See attached file: IM-0464.PDF)(See attached file: IM-0607.PDF)(See attached file: D04208201.dwg)(See attached file: C04209401.dwg)(See attached file: C04209402.dwg)(See attached file:

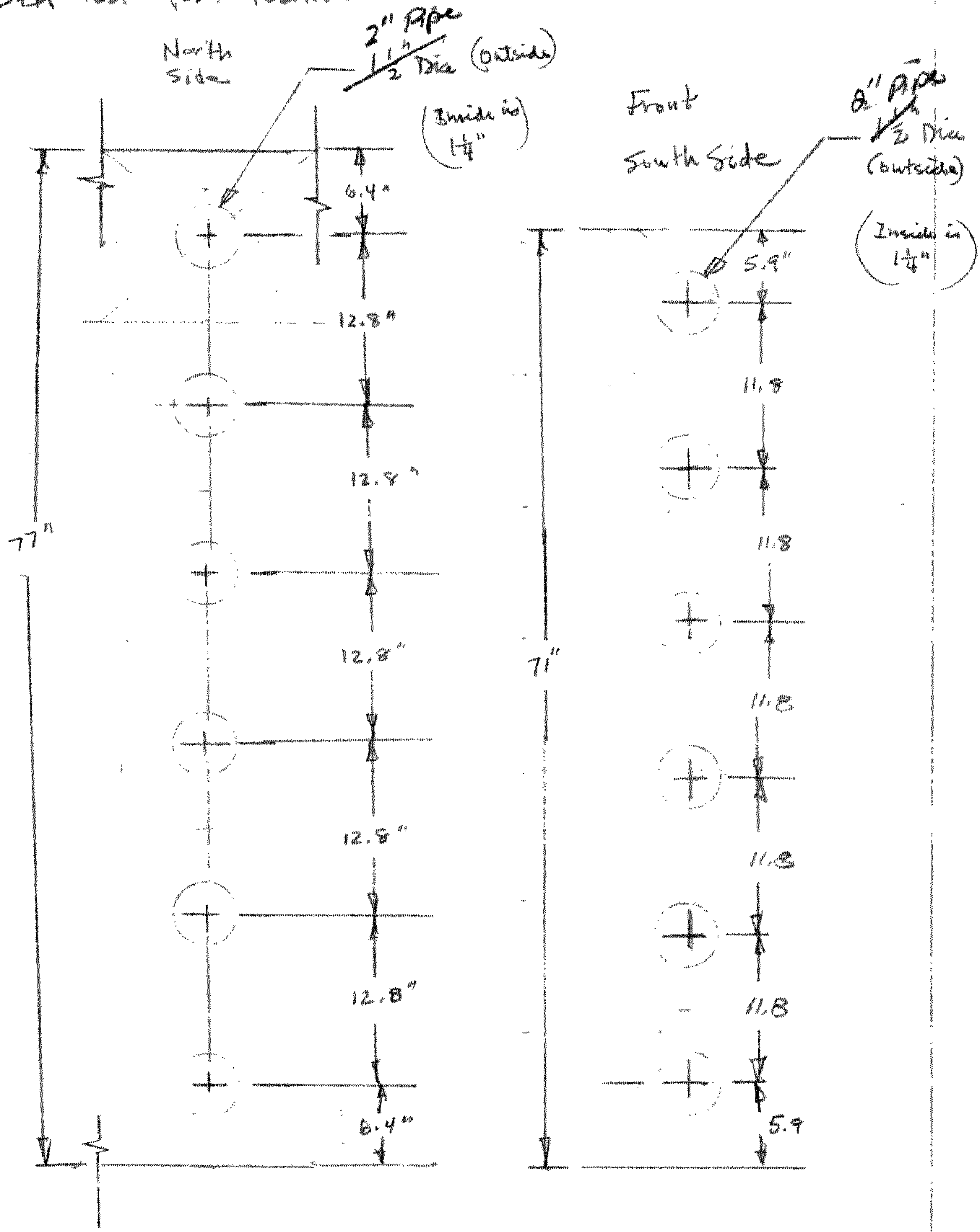
C04209403.dwg)

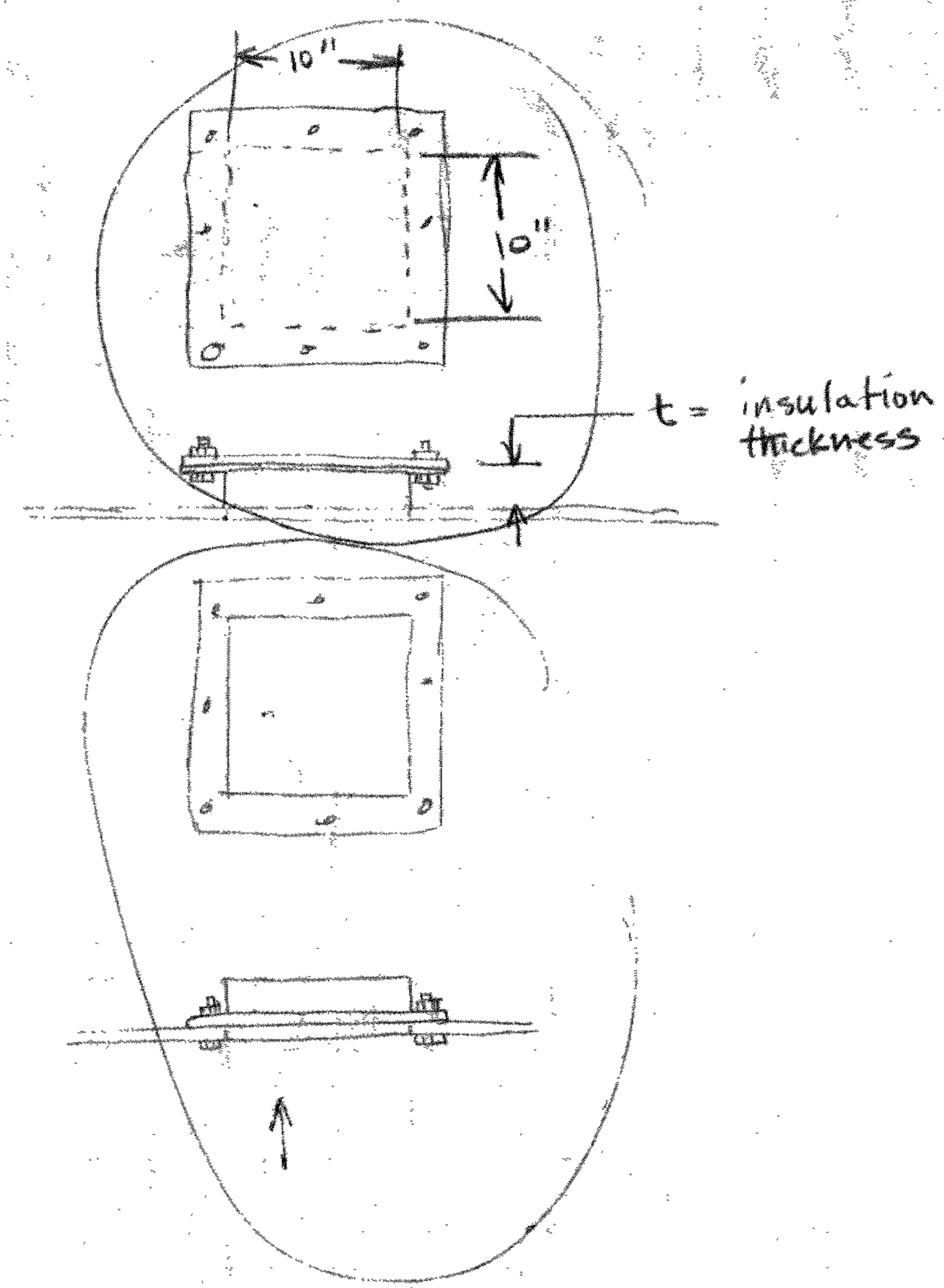
INTERMOUNTAIN POWER UNIT 1 Tubing for CAMS System - FIELD SKETCH



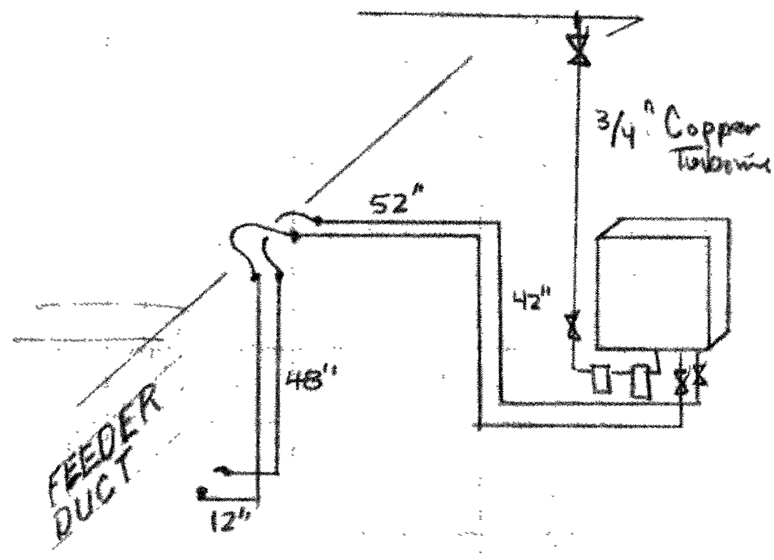


OEA Test Port Positions



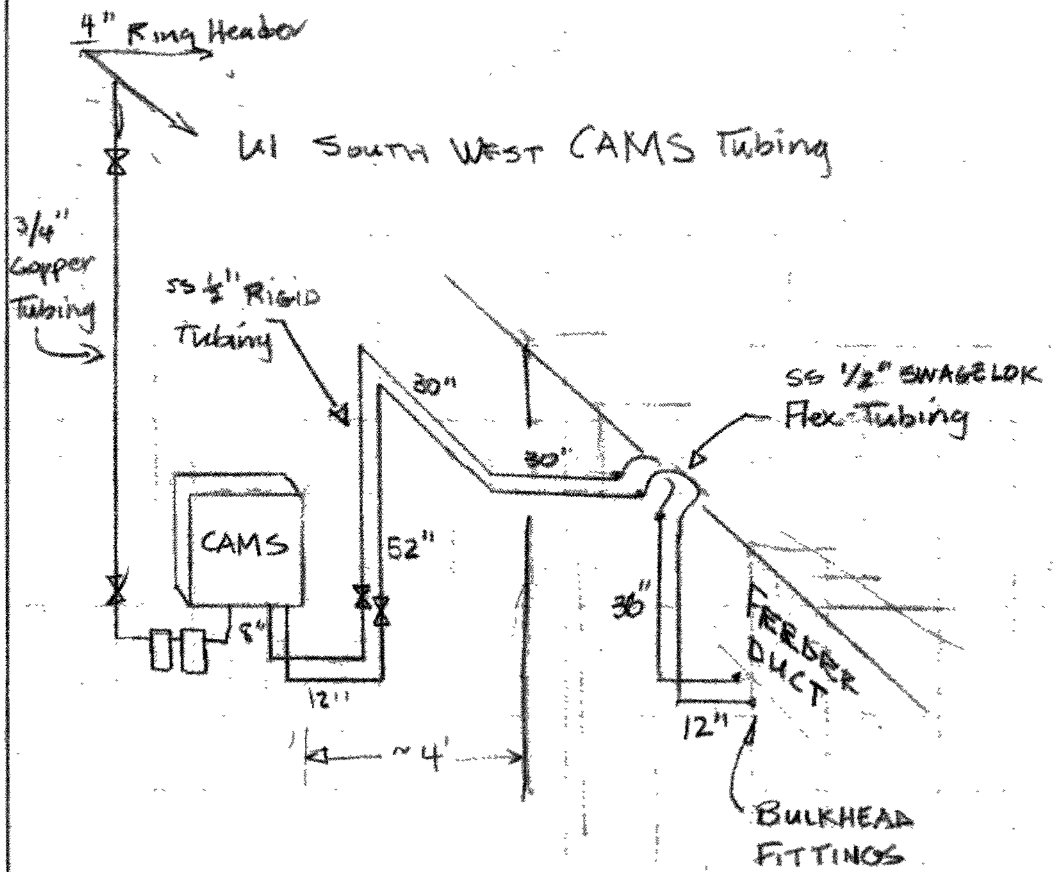

10"
10"
t = insulation thickness

INTERMOUNTAIN POWER UNIT 1 Tubing for CAMS System | FIELD SKETCH



SE CAMs

U1 South West CAMS Tubing



IGS02-14 OFA PROJECT
CCS SOFTWARE CBC
CONFIGURATION

8-B7	
CALC	
OP1	C28
OP2	+
OP3	C22
OP4	+
OP5	C34
OP6	+
OP7	C04
OP8	/
OP9	4
OP10	S3
OP11	M3
OP12	*
OP13	1.000
OP14	S2
OP15	M2
OP16	/
OP17	C12X
OP18	*
OP19	1.000
OP20	S1
OP21	=
OP22	
OP23	
OP24	
OP25	
OP26	
OP27	
OP28	
OP29	
OP30	
OP31	
OP32	
OP33	
OP34	
OP35	

8-B11	
CALC	
OP1	B29 01
OP2	*
OP3	-0.600
OP4	+
OP5	1.3
OP6	*
OP7	B10 01
OP8	S3
OP9	=
OP10	
OP11	
OP12	
OP13	
OP14	
OP15	
OP16	
OP17	
OP18	
OP19	
OP20	
OP21	
OP22	
OP23	
OP24	
OP25	
OP26	
OP27	
OP28	
OP29	
OP30	
OP31	
OP32	
OP33	
OP34	
OP35	

8-B21	
CALC	
OP1	B11 01
OP2	+
OP3	B20 01
OP4	*
OP5	1.000
OP6	S2
OP7	B11 01
OP8	*
OP9	1.000
OP10	S1
OP11	=
OP12	
OP13	
OP14	
OP15	
OP16	
OP17	
OP18	
OP19	
OP20	
OP21	
OP22	
OP23	
OP24	
OP25	
OP26	
OP27	
OP28	
OP29	
OP30	
OP31	
OP32	
OP33	
OP34	
OP35	

8-B26	
CALC	
OP1	B11 01
OP2	+
OP3	B25 01
OP4	*
OP5	1.000
OP6	S2
OP7	B11 01
OP8	+
OP9	B28 01
OP10	S1
OP11	=
OP12	
OP13	
OP14	
OP15	
OP16	
OP17	
OP18	
OP19	
OP20	
OP21	
OP22	
OP23	
OP24	
OP25	
OP26	
OP27	
OP28	
OP29	
OP30	
OP31	
OP32	
OP33	
OP34	
OP35	

8-B10	
PID	
MEAS	B07 01
OSET	0.0
OUT	
FBK	B10 01
ESET	B08 01
HA	100.0
LA	0.0
DB	2.0
HD	100.0
LD	100.0
DDB	2.0
HM	100.0
LM	0.0
MDB	0.0
PBAND	400.0
INT	5.0
GAIN	0.0
BIAS	0.0
HIRNG	
INC	
NOINT	
NODER	Y
INITC	
LOCP	0
REMP	0
SKIP	0
TRACK	0
MANP	1
AUTP	0
MLIM	Y

8-B14	
PID	
MEAS	C07X
OSET	25.0
OUT	C09
FBK	B14 01
ESET	0.000
HA	100.0
LA	0.0
DB	2.0
HD	100.0
LD	100.0
DDB	2.0
HM	100
LM	0.0
MDB	0.0
PBAND	200
INT	3
GAIN	0.000
BIAS	0.0
HIRNG	
INC	
NOINT	
NODER	Y
INITC	
LOCP	
REMP	
SKIP	
TRACK	
MANP	
AUTP	
MLIM	

8-B19	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	50.0
BIAS1	0.0
OUT	
FBK	C21
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

IGS02-14 OFA PROJECT
CCS SOFTWARE CBC
CONFIGURATION

8-B20	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	100.000
BIAS1	0
OUT	
FBK	B20 01
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B22	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	50.0
BIAS1	0.0
OUT	
FBK	C27
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B23	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	100.0
BIAS1	0.0
OUT	
FBK	B23 01
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B24	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	50.0
BIAS1	0.0
OUT	
FBK	C01
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B25	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	100.0
BIAS1	0.0
OUT	
FBK	B25 01
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B27	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	50.0
BIAS1	0.0
OUT	
FBK	C33
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B28	
AMB	
MEAS	C11X
GAIN	0.0
BIAS	100.0
BIAS1	0.0
OUT	
FBK	B28 01
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

IGS02-14 OFA PROJECT
CCS SOFTWARE CBC
CONFIGURATION

	8-B29	8-B30	8-B31	8-B32	8-B33	8-B34	8-B35
	AMB	AMB	AMB	AMB	AMB	AMB	AMB
MEAS	B10 01	B12 01	B13 01	B12 01	B13 01	B12 01	B13 01
GAIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BIAS	0.0	50.0	50.0	50.0	50.0	50.0	50.0
BIAS1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OUT							
FBK	0.0	C21X	C28X	C22X	C27X	C01X	C34X
TRACK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MOVRD							
MANP	1.0	0.0	0.0	0.0	0.0	0.0	0.0
AUTP	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HA	100.0	100.0	100.0	100.0	100.0	100.0	100.0
LA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB	2.0	2.0	2.0	2.0	2.0	2.0	2.0
HM	100.0	100.0	100.0	100.0	100.0	100.0	100.0
LM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BTIM	0.0	1.0	1.0	1.0	1.0	1.0	1.0
HIRNG							
FLNKA							
BTRK							
MLIM							
MBAD		Y	Y	Y	Y	Y	Y
INITC							

IGS02-14 OFA PROJECT
CCS SOFTWARE CBC
CONFIGURATION

8-B36	
AMB	
MEAS	B12 01
GAIN	0.0
BIAS	50.0
BIAS1	0.0
OUT	
FBK	C33X
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B37	
AMB	
MEAS	B13 01
GAIN	0.0
BIAS	50.0
BIAS1	0.0
OUT	
FBK	C02X
TRACK	0.0
MOVRD	
MANP	0.0
AUTP	0.0
HA	100.0
LA	0.0
DB	2.0
HM	100.0
LM	0.0
MDB	0.0
BTIM	1.0
HIRNG	
FLNKA	
BTRK	
MLIM	
MBAD	Y
INITC	

8-B8	
CHAR	
MEAS	C08
INITC	
X1	60.0
X2	100.0
X3	0.0
X4	0.0
X5	0.0
X6	0.0
X7	0.0
X8	0.0
X9	0.0
X10	0.0
X11	0.0
Y1	11.0
Y2	15.0
Y3	0.0
Y4	0.0
Y5	0.0
Y6	0.0
Y7	0.0
Y8	0.0
Y9	0.0
Y10	0.0
Y11	0.0

8-B12	
CHAR	
MEAS	C08
INITC	
X1	0.0
X2	59.0
X3	60.0
X4	74.0
X5	75.0
X6	100.0
X7	0.0
X8	0.0
X9	0.0
X10	0.0
X11	0.0
Y1	0.0
Y2	0.0
Y3	100.0
Y4	100.0
Y5	0.0
Y6	0.0
Y7	100.0
Y8	100.0
Y9	0.0
Y10	0.0
Y11	0.0

8-B13	
CHAR	
MEAS	C08
INITC	
X1	59.0
X2	74.0
X3	75.0
X4	100.0
X5	0.0
X6	0.0
X7	0.0
X8	0.0
X9	0.0
X10	0.0
X11	0.0
Y1	0.0
Y2	0.0
Y3	0.0
Y4	100.0
Y5	100.0
Y6	0.0
Y7	0.0
Y8	0.0
Y9	0.0
Y10	0.0
Y11	0.0

8-B15	
CHAR	
MEAS	C11
INITC	
X1	30.0
X2	80.0
X3	100.0
X4	0.0
X5	0.0
X6	0.0
X7	0.0
X8	0.0
X9	0.0
X10	0.0
X11	0.0
Y1	16.6
Y2	16.6
Y3	100.0
Y4	100.0
Y5	0.0
Y6	0.0
Y7	0.0
Y8	0.0
Y9	0.0
Y10	0.0
Y11	0.0

8-B16	
CHAR	
MEAS	C08
INITC	
X1	30.0
X2	80.0
X3	100.0
X4	0.0
X5	0.0
X6	0.0
X7	0.0
X8	0.0
X9	0.0
X10	0.0
X11	0.0
Y1	16.6
Y2	16.6
Y3	100.0
Y4	100.0
Y5	0.0
Y6	0.0
Y7	0.0
Y8	0.0
Y9	0.0
Y10	0.0
Y11	0.0

IGS02-14 OFA PROJECT
CCS SOFTWARE CBC
CONFIGURATION

8-B53	
IOBK	
IN1	C21
IN2	C27
IN3	C01
IN4	C33
IN5	
IN6	
IN7	
IN8	
OUT1	
OUT2	
OUT3	
OUT4	
OUT5	
OUT6	
OUT7	
OUT8	
1HA	100.0
1LA	0.0
1DB	0.0
2HA	100.0
2LA	0.0
2DB	0.0
3HA	100.0
3LA	0.0
3DB	0.0
4HA	100.0
4LA	0.0
4DB	0.0
5HA	100.0
5LA	0.0
5DB	0.0
6HA	100.0
6LA	0.0
6DB	0.0
7HA	100.0
7LA	0.0
7DB	0.0
8HA	100.0
8LA	0.0
8DB	0.0

8-B54	
IOBK	
IN1	C21X
IN2	C28X
IN3	C22X
IN4	C27X
IN5	C01X
IN6	C34X
IN7	C33X
IN8	C02X
OUT1	
OUT2	
OUT3	
OUT4	
OUT5	
OUT6	
OUT7	
OUT8	
1HA	100.0
1LA	0.0
1DB	0.0
2HA	100.0
2LA	0.0
2DB	0.0
3HA	100.0
3LA	0.0
3DB	0.0
4HA	100.0
4LA	0.0
4DB	0.0
5HA	100.0
5LA	0.0
5DB	0.0
6HA	100.0
6LA	0.0
6DB	0.0
7HA	100.0
7LA	0.0
7DB	0.0
8HA	100.0
8LA	0.0
8DB	0.0

8-B55	
IOBK	
IN1	C28
IN2	C22
IN3	C34
IN4	C02
IN5	C12X
IN6	
IN7	
IN8	
OUT1	
OUT2	
OUT3	
OUT4	
OUT5	
OUT6	
OUT7	
OUT8	
1HA	100.0
1LA	0.0
1DB	0.0
2HA	100.0
2LA	0.0
2DB	0.0
3HA	100.0
3LA	0.0
3DB	0.0
4HA	100.0
4LA	0.0
4DB	0.0
5HA	100.0
5LA	0.0
5DB	0.0
6HA	100.0
6LA	0.0
6DB	0.0
7HA	100.0
7LA	0.0
7DB	0.0
8HA	100.0
8LA	0.0
8DB	0.0

8-B56	
IOBK	
IN1	B19 01
IN2	B21 01
IN3	B22 01
IN4	B21 02
IN5	B24 01
IN6	B26 01
IN7	B27 01
IN8	B26 02
OUT1	C29
OUT2	C17
OUT3	C25
OUT4	C19
OUT5	C23
OUT6	C18
OUT7	C30
OUT8	C21
1HA	100.0
1LA	0.0
1DB	0.0
2HA	100.0
2LA	0.0
2DB	0.0
3HA	100.0
3LA	0.0
3DB	0.0
4HA	100.0
4LA	0.0
4DB	0.0
5HA	100.0
5LA	0.0
5DB	0.0
6HA	100.0
6LA	0.0
6DB	0.0
7HA	100.0
7LA	0.0
7DB	0.0
8HA	100.0
8LA	0.0
8DB	0.0

8-B59	
IOBK	
IN1	B30 01
IN2	B31 01
IN3	B32 01
IN4	B33 01
IN5	B34 01
IN6	B35 01
IN7	B36 01
IN8	B37 01
OUT1	C30
OUT2	C36
OUT3	C37
OUT4	C26
OUT5	C24
OUT6	C38
OUT7	C35
OUT8	C23
1HA	100.0
1LA	0.0
1DB	0.0
2HA	100.0
2LA	0.0
2DB	0.0
3HA	100.0
3LA	0.0
3DB	0.0
4HA	100.0
4LA	0.0
4DB	0.0
5HA	100.0
5LA	0.0
5DB	0.0
6HA	100.0
6LA	0.0
6DB	0.0
7HA	100.0
7LA	0.0
7DB	0.0
8HA	100.0
8LA	0.0
8DB	0.0

OVER-FIRE AIR EQUIPMENT

24 - 2SGB-CDR-169 SW OFA INLET DMPR DRV
26 - 2SGB-CDR-173 SW OFA 2/3 DMPR DRV
28 - 2SGB-CDR-177 SW OFA 1/3 DMPR DRV
30 - 2SGB-CDR-170 SE OFA INLET DMPR DRV
32 - 2SGB-CDR-169 SE OFA 2/3 DMPR DRV
34 - 2SGB-CDR-169 SE OFA 1/3 DMPR DRV
24 - 2SGB-CAB-12 SE OFA CAMS PANEL
24 - 2SGB-CAB-14 NE OFA CAMS PANEL

OVER-FIRE AIR EQUIPMENT

17 - 2SGB-CDR-171 NW OFA INLET DMPR DRV
19 - 2SGB-CDR-175 SW OFA 2/3 DMPR DRV
25 - 2SGB-CDR-179 SW OFA 1/3 DMPR DRV
27 - 2SGB-CDR-172 NE OFA INLET DMPR DRV
29 - 2SGB-CDR-176 NE OFA 2/3 DMPR DRV
31 - 2SGB-CDR-180 NE OFA 1/3 DMPR DRV
33 - 2SGB-CAB-11 SW OFA CAMS PANEL
35 - 2SGB-CAB-13 NW OFA CAMS PANEL

IGS02-14: Over Fire Air Project - UCM Modifications

I. Isochronous Trip Items for Removal (Can be done prior to shutdown)

A. Hardware

1. Slide links leads for UCM13, 2COA-CAB-0003, A3-Section A9 in the following order:
    a. TB-2: 1,2; 5,6; 7,8(should be already open); 13,14; 15,16 (should be already open); 17,18; and 19,20;
    b. TB-1: 79,80; 81,82; 83,84; and 85,86.
    c. TB-1: 1,2; 3,4; 5,6; and 7,8.

2. De-terminate and tape the cables specified per dwg. 2COA-K2810 Rev.2 with markups at the locations specified below. Determinate and tape opposite ends of cables as well.
    a. UCM13, TB-1: 1,2; 3,4; 5,6; 7,8; 79,80; 81,82; 83,84; 85,86.
    b. UCM13, TB-2: 1,2; 5,6; 7,8; 15,16; 17,18; 19,20; 21,22.

3. Determinate and remove the following internal wiring to UCM13,, 2COA-CAB-0003, A3-Section A9:
    a. UCM13, TB-1:
        1 - term1,2 to 13-1-1-1;
        2 - term 3,4 to 13-1-1-2;
        3 - term 5,6 to 13-1-1-3;
        4 - term 7,8 to 13-1-1-4;
        5 - term 79,80 to 13-1-2-1;
        6 - term 81,82 to 13-1-2-2;
        7 - term 83,84 to 13-1-2-3;
        8 - term 85,86 to 13-1-2-4;

    b. UCM13, TB-2:
        1 - term 1,2 to R1 to 13-1-3-1;
        2 - term 5,6 to R3 to 13-1-3-5;
        3 - term 7,8 to R4 to 13-1-3-6;
        4 - term 15,16 to R4 to 13-1-3-6;
        5 - term 17,18 to R7 to 13-1-3-7;
        6 - term 19,20 to R7 to 13-1-3-7;
        7 - term 21,22 to R1 to 13-1-3-1; already de-termed on field side.

    c. UCM13, points direct wired, not wired through the Tbs.
        1 - From UCM09-3-7-6 to 13-1-3-2
        2 - From UCM02-3-8-4 to 13-1-2-5
        3 - From UCM01-1-3-2 direct wire to (UCM13)13-1-4-1

B. Software:

To be provided later.

1. Remove the following blocks from UCM13 CBC:
    a. Logic blocks: B1, B16, B31, B59
    b. H/L Selector: B9,
    c. DTIM blocks: B5, B6,
    d. COMP blocks: B11,B12,B13
    e. f(x) blocks: B7,B8,
2. Remove the following selector blocks from the UCM01 CBC:

II. UCM 13 Installation

1. Hardware:
    a. Install 3A2-D2I modules in UCM13:
        1 - Nest 1, Columns 9 & 10.
        2 - Nest 2, Columns 2, 3, 5, 6, 8, & 9.
    b. Install 3A4-I2D modules in UCM13
        1 - Nest 2, Columns 1, 4, & 7.
    c. Install wiring internal in UCM13 as indicated below:
        1 - TB1:1,2 to 13-2-5-1
        2 - TB1:3,4 to 13-2-1-1
        3 - TB1:5,6 to 13-2-8-2
        4 - TB1:7,8 to 13-2-4-4
        5 - TB1:27,28 to 13-2-1-3
        6 - TB1:29,30 to 13-2-5-2
        7 - TB1:31,32 to 13-2-9-1
        8 - TB1:33,34 to 13-2-1-4
        9 - TB1:35,36 to 13-2-3-1
        10 - TB1:37,38 to 13-2-4-1
        11 - TB1:39,40 to 13-2-3-2
        12 - TB1:41,42 to 13-2-4-3
        13 - TB1:43,44 to 13-2-2-1
        14 - TB1:45,46 to 13-1-1-1
        15 - TB1:47,48 to 13-2-9-2
        16 - TB1:49,50 to 13–27-4
        17 - TB1:51,52 to 13-2-2-2
        18 - TB1:53,54 to 13-1-1-3
        19 - TB1:55,56 to 13-2-8-1
        20 - TB1:57,58 to 13-2-7-3
        21 - TB1:59,60 to 13-2-6-1
        22 - TB1:61,62 to 13-2-7-1
        23 - TB1:63,64 to 13-2-6-2
        24 - TB1:65,66 to 13-1-1-2
        25 - TB1:67,68 to 13-2-4-2
        26 - TB1:69,70 to 13-2-1-2
        27 - TB1:71,72 to 13-2-7-2
        28 - TB1:73,74 to 13-1-1-2
        29 - TB1:75,76 to 13-1-9-1

30 - TB1:77,78 to 13-1-10-1
31 - TB1:79,80 to 13-1-9-1
32 - TB1:81,82 to 13-1-10-2
33 - TB1:83,84 to 13-1-6-3
34 - TB1:85,86 to 13-1-6-4

Unit 2	Start Time		5/16/2002 14 00			
	End Time		5/16/2002 17:00			
			Test 1			**A**
			average	maximum	minimum	
Load	2COAXI027A		952.89	961.24	943.75	
	2TGBPK0022		952.29	960.82	943.24	
Aux Power	2APEKV0005		52.28	53.70	50.40	
TEMPERATURES Air/Gas						
Fan Room Outside Temp	2SGBTE1160	Deg F	75.45	77.64	73.66	
Fan Room Temp	2SGBTE1065	Deg F	76.02	77.29	74.47	
Air Temp Ent SAH 1A	2COAXI124A	Deg F	85.33	87.51	83.03	
Air Temp Ent SAH 1B	2COAXI125A	Deg F	84.38	86.45	81.70	
Air Temp Ent PAH 2A	2SGBTE0911	Deg F	124.77	126.06	123.12	
Air Temp Ent PAH 2B	2SGBTE0912	Deg F	125.79	127.57	124.11	
Air Temp Lvg SAH 1A	2COAXI149A	Deg F	664.62	667.86	660.61	
Air Temp Lvg SAH 1B	2COAXI150A	Deg F	663.07	664.65	661.27	
Air Temp Lvg PAH 2A	2SGBTE0917	Deg F	533.74	535.03	530.79	
Air Temp Lvg PAH 2B	2SGBTE0918	Deg F	543.35	545.23	540.68	
Flame Gas Temp	2SGAPX3571	Deg F	3676.76	3730.70	3598.13	
SSH Platens Gas Out Temp	2SGAPX3582	Deg F	2216.62	2243.60	2160.22	
SSH Int Gas In Temp	2SGAPX3591	Deg F	2216.62	2243.60	2160.22	
SSH Int Gas Out Temp	2SGAPX3592	Deg F	1884.88	1921.45	1821.10	
SSH Outlet Bank Gas Out Temp	2SGAPX3602	Deg F	1718.15	1753.47	1653.74	
RH Outlet Bank Gas Out Temp	2SGAPX3612	Deg F	1480.78	1513.72	1435.47	
Pri RH Banks Gas In Temp	2SGAPX3641	Deg F	1508.05	1537.16	1466.48	
RH Section Gas Out Temp	2SGATE1631	Deg F	754.18	761.05	742.81	
PSH Outlet Gas Temp	2SGAPX3622	Deg F	934.72	944.93	925.57	
Econ Section Gas Out Temp	2SGATE1625	Deg F	735.98	741.19	727.41	
Gas Temp Ent SAH 1A	2SGATE1650	Deg F	746.55	749.70	741.60	
Gas Temp Ent SAH 1B	2SGATE1651	Deg F	751.52	755.38	745.24	
Ave Econ Exit Gas Temp	2SGAPX3015	Deg F	749.02	752.67	743.44	
Gas Temp LVG SAH 1A	2COAXI122A	Deg F	312.45	313.88	310.35	
Gas Temp Lvg SAH 1B	2COAXI123A	Deg F	310.30	312.25	308.09	
TEMPERATURES Stm/Wtr						
BBFP Suction Temp	2FWATE0045		347.39	347.39	347.39	
BFP Suction Temp	2FWATE0046		345.55	346.13	344.56	
	2FWATE0047		346.53	347.08	345.66	
	2FWATE0048		345.51	345.51	345.51	
BFP Discharge Temp	2FWATE0049		353.14	353.83	352.10	
	2FWATE0050		353.99	354.77	352.88	
	2FWATE0051		339.25	340.78	337.97	
SH Desuperheater Spray Temp	2COAXI026A		367.73	368.86	366.44	
	2SGATE0991		347.81	348.82	347.20	
HP FW Htr Inlet Temp	2FWATE0052		351.77	352.41	350.84	
Econ Inlet Water Temp	2COAXI025A		549.00	549.90	547.94	
	2FWATE0990		548.44	549.16	547.59	
TSAT at Drum Pressure	2SGAPX3261		677.67	680.10	676.95	
1st Stage SH Attemp Inlet Temp	2SGATE0863		720.07	723.76	715.25	
	2SGATE0864		722.65	727.01	716.06	
1st Stage SH Attemp Outlet Temp	2COAXI098A		719.28	723.25	714.37	
	2COAXI099A		723.58	728.50	716.37	
2nd Stage SH Attemp Inlet Temp	2SGATE0871		776.94	783.75	768.34	
	2SGATE0872		786.24	796.77	773.61	
2nd Stage SH Attemp Outlet Temp	2COAXI093A		773.82	781.34	765.00	
	2COAXI094A		783.90	794.13	771.50	
SSH Int Bank Outlet Temp	2SGATE0514		902.35	909.43	885.12	
Main Steam Temp	2COAXI015A		999.01	1006.20	982.65	
Cold Reheat Inlet Temp	2SGJTE0019		629.27	634.60	616.36	
	2SGJTE0022		629.99	635.41	617.17	

Pri RH Section Steam Out Temp	2SGATE1637		815.89	827.57	797.17
RH Turbine Inlet Temp East	2COAXI104A		1003.77	1017.90	983.86
RH Turbine Inlet Temp West	2COAXI105A		998.64	1012.66	979.35
Blr Hot Reheat Temp Ave	2COAXI046A		1004.44	1018.96	984.30
Steam Temp Pickup					
Drum thru PSH	2SGAPE0001		43.65	48.30	35.94
Platens	2SGAPE0002		60.05	65.58	55.60
SSH Int Bank	2SGAPE0003		138.05	147.70	131.08
SSH Out Bank	2SGAPE0004		82.09	87.62	76.83
Pri RH Section	2SGAPE0005		186.15	193.35	175.51
RH Outlet	2SGAPE0006		185.32	189.55	173.94
PRESSURES Stm/Wtr					
BFP Suction Pressure	2FWAPT0028		300.00	300.00	300.00
BFP 1A Discharge Pressure	2FWAPT0029		2921.33	2973.72	2886.20
BFP 1B Discharge Pressure	2FWAPT0030		2921.34	2973.72	2888.76
HP Htr Inlet Pressure	2FWAPT0250		2881.77	2932.39	2850.35
Econ Inlet Pressure	2FWAPT0032		2744.92	2795.01	2717.49
Drum Pressure	2COAXI043A		2654.11	2703.73	2628.01
PSH Outlet Pressure	2SGAPT0195		2588.37	2639.09	2563.10
	2SGAPT0196		2588.78	2640.00	2564.10
SSH Platen Outlet Pressure	2SGAPT0198		2560.19	2613.73	2534.99
	2SGAPT0199		2557.52	2609.97	2531.24
Main Steam Pressure	2COAXI012A		2345.85	2403.57	2320.80
	2SGGPT0001		2351.03	2409.38	2326.88
Steam Chest Pressure	2TGAPT0040		2310.20	2365.98	2290.99
1st Stage Inlet Pressure	2COAXI042S		2272.34	2297.97	2252.41
HP section Exhaust Pressure	2SGJPT0012		596.32	602.24	590.50
	2COAXI171A		594.08	599.99	588.20
Cold Reheat Inlet Pressure	2SGJPT0009		590.60	596.26	586.13
	2SGJPT0011		591.53	596.50	587.00
Hot Reheat Outlet Pressure	2SGJPT0006		555.92	561.49	550.26
	2SGJPT0007		554.72	560.49	548.99
RH Steam Pressure	2SGJPT0045		542.35	547.01	538.99
Turb RH Bowl Press	2SGJPT0049		551.19	557.00	545.50
PMAX RH Pressure Drop	2SGAPX3356		6.72	6.73	6.72
Fox 1A RH Pressure Drop	2INAKV0021		6.75	7.08	6.39
AIR FLOWS					
Total Fuel Flow	2COAXI001A	TPH	368.52	378.41	360.09
Total Air Flow %	2COAXI078S	%	88.28	90.27	85.55
RH Bias Damper Pos %	2COAXI136A	%	89.73	99.59	64.82
SH Bias Damper Pos %	2COAXI135A	%	92.90	92.90	92.90
FD Fan 1A Blade Pitch	2COAXI153A	%	63.59	64.53	60.95
FD Fan 1B Blade Pitch	2COAXI154A	%	63.28	64.90	60.90
Sec Air Flow 1A	2COAXI076R	%	79.71	81.65	77.25
Sec Air Flow 1B	2COAXI077R	%	81.51	83.15	79.05
FD Fan 1A D/P	2SGBPT0218		12.08	12.63	11.47
FD Fan 1B D/P	2SGBPT0219		12.58	13.13	12.13
FD Fan 1A Amps	2SGBKK0005	Amps	237.29	240.06	229.32
FD Fan 1B Amps	2SGBKK0006	Amps	226.84	233.39	218.58
East Flue Gas O2	2COAXI079A	%	2.37	5.61	1.91
West Flue Gas O2	2COAXI080A	%	2.34	4.09	1.98
Selected Econ Out O2	2COAXI187A	%	2.35	4.00	2.06
Stack NOx Converted	2SAAKK0007		0.44	0.46	0.43
Blr Total Gas Flow	2SGAPX3520	Lb/hr	7925507	8192206	7712089
Blr Econ Gas Flow	2SGAPX3660	Lb/hr	5054294	5218116	4804193
Blr RH Gas Flow	2SGAPX3661	Lb/hr	2871627	2973968	2776696
CEM Stack Vol Flow (MMSCFH)	2SAAKK0016		152.22	156.34	146.57
PMAX Stack Vol Flow (MMSCFH)	2SGAPX3903		134.99	139.56	131.42

FLOWS Wtr/Stm					
Feedwater Flow (Fox 1A pt)	2FWAFT0025	KPPH	6724.80	6952.79	6485.58
Feedwater Flow (CCS pt)	2COAXI021A	KPPH	6737 78	6975.43	6499.47
Total Sprays (CCS)	2COAXI022A	KPPH	21.16	37.63	7.87
Total Sprays (PMAX)	2SGAPX3033	KPPH	20.70	35.86	9.95
Steam Flow (FFW + Sprays)	2COAXI023A	KPPH	6758.50	6992.95	6525.74
Steam Flow off 1st Stage	2COAXI024A	KPPH	6760.34	6833.80	6702.41
PMAX Throttle Flow	2FWAPX3352	KPPH	6760.16	6884.64	6666.10
RH Spray Flow	2COAXI108A	KPPH	8.39	10.00	6.30
BFP 1A Flow	2FWAFT0008	KPPH	3351.08	3396.95	3306.74
BFP 1B Flow	2FWAFT0009	KPPH	3319.09	3367.17	3258.40
BFP 1C Flow	2FWAFT0010	KPPH	0.00	0.00	0.00
BBFP 2A Flow	2FWAFT0001	KPPH	2390.20	2471.27	2282.54
BBFP 2B Flow	2FWAFT0006	KPPH	2254.94	2338.69	2178.78
BBFP 2C Flow	2FWAFT0007	KPPH	2275.89	2368.72	2192.45
PMAX CRH Flow	2INAPX3066	Lb/hr	5547688	5649001	5469503
COLD REHEAT FLOW(3-1)	2INAPX3325	Lb/hr	5549647	5649782	5470870
BLR PRESSURES					
FURNACE PRESS	2COAXI083A	INWC	-0.52	0.81	-0.98
WW GAS OUT PRESS	2SGAPX3836	INWC	-0.51	-0.13	-0.95
SSH PLATEN GAS OUT PRESS	2SGAPX3837	INWC	-0.51	-0.13	-0.95
SSH INT BANK GAS OUT PRESS	2SGAPX3838	INWC	-0.55	-0.17	-0.99
SSH OUT BANK GAS OUT PRESS	2SGAPX3839	INWC	-0.72	-0.33	-1.16
FIN RH GAS OUT PRESS	2SGAPX3840	INWC	-1.80	-1.30	-2.22
HORIZ RH GAS OUT PRESS	2SGAPX3843	INWC	-3.57	-2.93	-4.02
PSH GAS OUT PRESS	2SGAPX3841	INWC	-3.03	-2.44	-3.47
ECON GAS OUT PRESS	2SGAPX3842	INWC	-3.32	-2.70	-3.76
SECONDARY AIR DUCT (E) PRE	2SGBPT0256	INWC	3.67	4.86	3.19
SECONDARY AIR DUCT (W) PRE	2SGBPT0257	INWC	4.21	5.00	3.73
FURNACE PRESS	2COAXI083A	INWC	-0.52	0.81	-0.98
SG EAST FLUE GAS PR	2SGAPT0171	INWC	-0.54	1.01	-0.75
SG SEC SUPHTR FLUE GAS PR	2SGAPT0169	INWC	-1.22	0.26	-1.73
SG HORIZ RH OUT FL GS PR	2SGAPT0167	INWC	-3.58	-1.97	-4.21
SG PENDANT OUTLT FL GS PR	2SGAPT0168	INWC	-1.87	-0.30	-2.46
SG PRI SUPHTR OUT FL GS PR	2SGAPT0166	INWC	-2.92	-1.34	-3.53
SG ECON OUTLET FLUE GAS PR	2SGAPT0165	INWC	-3.33	-1.71	-4.07
SEC AH 1A INLET PRESS	2SGAPT0164	INWC	-4.77	-3.17	-5.49
SEC AH 1B INLET PRESS	2SGAPT0183	INWC	-4.73	-3.11	-5.51
ID FANS SUCT PRESS	2COAXI084A	INWC	-24.01	-21.19	-25.87
ID FAN 1A OUTLET PR	2CCEPT0115	INWC	5.44	5.91	4.38
ID FAN 1B OUTLET PR	2CCEPT0116	INWC	5.11	6.17	4.51
ID FAN 1C OUTLET PR	2CCEPT0117	INWC	5.43	6.08	4.64
ID FAN 1D OUTLET PR	2CCEPT0118	INWC	5.28	6.26	4.18
U1 CASING A DELTA PRESS	2CCBA40001	INWC	8.00	9.37	7.16
U1 CASING B DELTA PRESS	2CCBB40001	INWC	8.30	9.22	7.62
U1 CASING C DELTA PRESS	2CCBC40001	INWC	7.87	8.85	7.14
Boiler Heat Duty	2SGAPX3563	MBTU/H	7410.42	7525.04	7281.41
Water Walls Heat Duty	2SGAPX3690	MBTU/H	3285.14	3342.08	3252.97
SSH Platens Heat Duty	2SGAPX3691	MBTU/H	537.45	568.01	511.06
SSH Int Heat Duty	2SGAPX3692	MBTU/H	818.49	880.40	770.35
SSH Out Heat Duty	2SGAPX3693	MBTU/H	405.50	426.47	380.63
RH Outlet Heat Duty	2SGAPX3694	MBTU/H	568.32	585.65	521.56
PSH Heat Duty	2SGAPX3695	MBTU/H	800.35	843.23	739.16
Econ Heat Duty	2SGAPX3696	MBTU/H	277.13	287.85	269.40
Pri RH Heat Duty	2SGAPX3697	MBTU/H	621.67	645.71	591.81

Blr Section Heat Duty Summation	Calc	MBTU/H		Tag not found:	Tag not found: -5
Blr Absorption Efficiency	Calc	%			
Boiler In-Out Efficiency	2SGAPX3561		86.16	87.74	84.74
Boiler Heat Loss Efficiency	2SGAPX3550		89.27	89.36	89.07
Cleanliness					
Waterwalls	2SGAPX3577		0.80	0.83	0.78
SH Primary Bank	2SGAPX3628		0.87	0.90	0.83
SSH Platens	2SGAPX3587		0.73	0.78	0.68
SSH Intermediate Bank	2SGAPX3598		0.80	0.87	0.75
SSH Outlet Bank	2SGAPX3608		0.65	0.72	0.60
RH Primary Banks	2SGAPX3648		0.86	0.90	0.84
RH Outlet Banks	2SGAPX3618		0.86	0.91	0.80
Econ Banks	2SGAPX3638		0.88	0.93	0.85
Flame Temp	2SGAPX3571		3677	3730.70	3598.13
FEGT	2SGAPX3572		2217	2243.60	2160.22
Backpass Inlet	2SGAPX3665		1505	1656.42	1450.97
Pulverizer Data	2COAXI001A	Total TF	368.52	378.41	360.09
Pulv 1A Coal Flow (TPH)	2COAXI002A		53.33	56.03	51.05
Pulv 1B Coal Flow (TPH)	2COAXI003A		54.18	56.19	52.04
Pulv 1C Coal Flow (TPH)	2COAXI004A		50.61	52.68	48.53
Pulv 1D Coal Flow (TPH)	2COAXI005A		0.10	0.10	0.10
Pulv 1E Coal Flow (TPH)	2COAXI006A		53.97	56.24	51.77
Pulv 1F Coal Flow (TPH)	2COAXI007A		52.90	57.53	48.70
Pulv 1G Coal Flow (TPH)	2COAXI008A		53.84	57.00	51.08
Pulv 1H Coal Flow (TPH)	2COAXI009A		49.84	52.26	47.26
Pulv 1A PA Damper Pos	2COAKS021A		78.79	79.40	77.87
Pulv 1B PA Damper Pos	2COAKS022A		68.97	69.75	68.00
Pulv 1C PA Damper Pos	2COAKS023A		70.89	72.08	70.20
Pulv 1D PA Damper Pos	2COAKS024A		0.00	0.00	0.00
Pulv 1E PA Damper Pos	2COAKS025A		71.58	72.13	70.53
Pulv 1F PA Damper Pos	2COAKS026A		76.09	81.12	71.37
Pulv 1G PA Damper Pos	2COAKS027A		75.57	76.27	74.58
Pulv 1H PA Damper Pos	2COAKS028A		78.71	79.20	77.22
Pulv 1A Inlet PA Temp	2SGATE0639		309.94	310.81	307.20
Pulv 1B Inlet PA Temp	2SGATE0640		316.95	323.68	305.94
Pulv 1C Inlet PA Temp	2SGATE0641		298.17	303.90	291.79
Pulv 1D Inlet PA Temp	2SGATE0642		97.21	100.18	93.01
Pulv 1E Inlet PA Temp	2SGATE0643		312.85	316.46	310.62
Pulv 1F Inlet PA Temp	2SGATE0644		336.09	341.22	322.95
Pulv 1G Inlet PA Temp	2SGATE0645		318.43	325.57	307.24
Pulv 1H Inlet PA Temp	2SGATE0646		293.50	299.51	284.75
Pulv 1A Outlet Temp	2COAXI064A		150.64	151.10	150.00
Pulv 1B Outlet Temp	2COAXI065A		153.68	154.10	153.03
Pulv 1C Outlet Temp	2COAXI066A		150.57	150.60	150.38
Pulv 1D Outlet Temp	2COAXI067A		87.30	88.60	86.11
Pulv 1E Outlet Temp	2COAXI068A		151.21	151.25	151.01
Pulv 1F Outlet Temp	2COAXI069A		148.70	149.35	148.40
Pulv 1G Outlet Temp	2COAXI070A		149.97	150.95	149.35
Pulv 1H Outlet Temp	2COAXI071A		150.23	151.40	148.90
Calculated Mass Flow lb/min					
Pulv 1A	2SGBPE0056		3637.64	3654 81	3620.47
Pulv 1B	2SGBPE0057		3592.03	3592.30	3591.75

Pulv 1C	2SGBPE0058	3745.98	3752.48	3709.99
Pulv 1D	2SGBPE0059	334.93	340.88	329.07
Pulv 1E	2SGBPE0060	3632.54	3641.35	3564.30
Pulv 1F	2SGBPE0061	3592.53	3595.90	3567.23
Pulv 1G	2SGBPE0062	3887.37	3890.39	3861.44
Pulv 1H	2SGBPE0063	3955.93	4000.09	3911.78
Windbox Pos				
Pulv 1A	2COAKS007A	79.23	82.30	76.55
Pulv 1B	2COAKS003A	79.06	82.17	76.23
Pulv 1C	2COAKS005A	74.08	77.50	71.22
Pulv 1D	2COAKS009A	55.21	57.12	40.75
Pulv 1E	2COAKS010A	79.65	82.20	76.88
Pulv 1F	2COAKS006A	79.15	81.80	76.25
Pulv 1G	2COAKS004A	79.27	82.27	76.25
Pulv 1H	2COAKS008A	72.52	75.40	69.65
PA Flow %				
Pulv 1A	2COAXI056A	92.46	93.05	91.92
Pulv 1B	2COAXI057A	90.96	91.88	90.35
Pulv 1C	2COAXI058A	94.76	95.85	93.43
Pulv 1D	2COAXI059A	8.45	8.73	8.10
Pulv 1E	2COAXI060A	91.78	92.28	91.15
Pulv 1F	2COAXI061A	90.71	91.60	89.95
Pulv 1G	2COAXI062A	97.90	98.38	97.42
Pulv 1H	2COAXI063A	99.45	99.60	99.30
Pulv air Bias				
Pulv 1A	2COAXI211A	0.00	0.00	0.00
Pulv 1B	2COAXI212A	0.00	0.00	0.00
Pulv 1C	2COAXI213A	5.69	5.69	5.69
Pulv 1D	2COAXI214A	0.00	0.00	0.00
Pulv 1E	2COAXI215A	0.00	0.00	0.00
Pulv 1F	2COAXI216A	0.00	0.00	0.00
Pulv 1G	2COAXI217A	6.60	6.60	6.60
Pulv 1H	2COAXI218A	14.07	14.07	14.07
Pulv Coal Bias				
Pulv 1A	2COAXI221A	0.00	0.00	0.00
Pulv 1B	2COAXI222A	0.00	0.00	0.00
Pulv 1C	2COAXI223A	-4.00	-4.00	-4.00
Pulv 1D	2COAXI224A	0.00	0.00	0.00
Pulv 1E	2COAXI225A	0.00	0.00	0.00
Pulv 1F	2COAXI226A	0.00	0.00	0.00
Pulv 1G	2COAXI227A	0.00	0.00	0.00
Pulv 1H	2COAXI228A	-5.00	-5.00	-5.00
Drum Level	2COAXI019S	0.31	1.95	-1.11
SAH 1A Flue Gas Out O2	2SGBAZ0022	5.57	6.13	5.06
SAH 1B Flue Gas Out O2	2SGBAZ0023	4.46	4.58	4.30
East Flue Gas O2	2COAXI079A	2.37	5.61	1.91
West Flue Gas O2	2COAXI080A	2.34	4.09	1.98
Econ O2 Out	2COAXI187A	2.35	4.00	2.06
RH Bias Damper Pos	2COAXI136A	89.73	99.59	64.82
Econ/PSH Bias Damper Pos	2COAXI135A	92.90	92.90	92.90

5/16/2002 14:00			5/17/2002 7:30		
5/16/2002 23.00			5/17/2002 13:00		
fternoon day 1			**Day 2**		
average	maximum	minimum	average	maximum	minimum
952.67	962.74	940.49	950.49	962.25	938.26
952.09	962.23	939.02	949.95	961.54	937.61
52.86	54.60	50.40	51.86	53.70	50.10
75.05	82.18	65.38	66.43	75.10	56 60
76.05	78.41	70.25	67.96	74.73	61.47
84.12	87.51	75.42	77.40	85.28	67.65
83.83	86.73	75.67	76.03	84.72	66.12
123.97	126.63	116.56	118.82	125.81	110.32
124.85	127.57	117.28	118.96	127.24	109.11
669.87	677.31	660.61	654.18	659.35	648.81
667.81	674.70	661.27	657.55	662.17	651.63
537.87	543.19	530.79	537.96	541.94	532.20
547.17	553.60	540.52	546.19	551.51	541.31
3703.51	3759.64	3598.13	3793.42	3862.67	3723.01
2233.49	2273.87	2160.22	2245.47	2275.70	2196.48
2233.49	2273.87	2160.22	2245.47	2275.70	2196.48
1903.00	1944.88	1821.10	1895.84	1923.40	1863.95
1738.70	1777.64	1653.74	1726.00	1751.76	1690.12
1499.60	1532.52	1435.47	1494.89	1519.70	1460.49
1526.67	1558.15	1466.48	1522.41	1546.19	1491.13
759.38	770.78	742.81	741.75	754.57	729.44
945.70	959.38	925.57	939.52	950.35	925.93
742.49	753.35	727.41	730.83	737.54	717.68
752.24	763.08	741.60	741.18	748.49	729.03
757.89	769.16	745.24	742.01	750.51	729 84
754.96	765.72	743.44	741.58	748.86	730.26
313.27	317.10	310.35	304.02	309.50	296.83
311.68	313.88	308.09	301.49	306.85	295.51
347.77	348.33	347.39	348.18	348.44	347.86
345.63	346.45	344.56	345.65	346.45	344.56
346.60	347.23	345.51	346.68	347.39	345.82
345.65	346.13	345.44	345.94	346.31	345.74
353.21	354.14	352.10	353.35	354.30	352.26
354.05	354.92	352.73	354.23	355.08	353.04
340.51	341.27	337.97	341.14	341.48	340.95
367.26	369.34	365.25	361.40	362.82	361.20
347.41	349.32	345.58	342.50	344.03	342.34
351.84	352.57	350.84	352.05	353.04	351.00
549.08	549.90	547.94	548.74	549.90	547.50
548.49	549.16	547.59	548.14	549.16	546.96
677.38	680.10	676.61	678.35	679.00	677.80
720.49	724.57	715.25	715.07	718.49	711.60
723.66	727.82	716.06	717.35	720.12	715.25
719.89	723.76	714.37	713.91	717.26	710.75
724.44	729.37	716.37	716.64	720.87	714.00
778.80	784.96	768.34	768.00	775.23	763.08
789.56	796.77	773.61	777.53	786.63	771.99
775.60	783.62	765.00	765.15	773.12	759.37
787.30	794.13	771.50	776.00	785.25	769.00
905.30	912.27	885.12	891.85	906.19	884.31
1000.08	1008.91	982.65	980.10	997.64	966.44
630.48	635.41	616.36	613.39	626.09	603.80
631.18	636.22	617.17	614.15	626.49	605.01

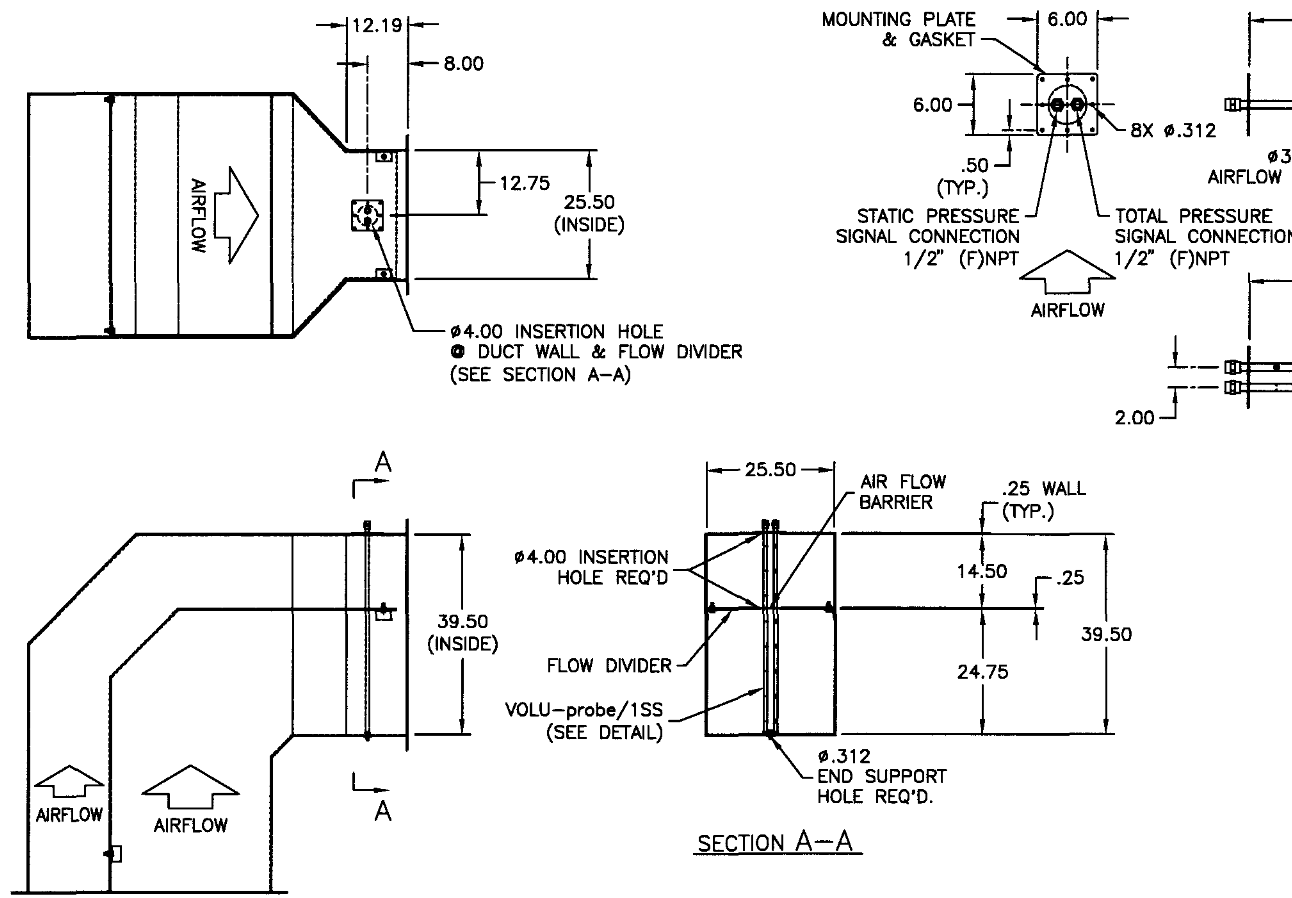
818.16	827.57	797.17	803.54	818.65	794.00
1006.28	1017.90	983.86	975.42	989.55	960.00
1001.17	1012.66	979.35	970.87	984.61	955.49
1006.93	1018.96	984.30	976.24	990.30	961.06
44.68	49.42	35.94	37.93	40.81	34.93
61.99	67.00	55.60	57.59	62.08	54.18
138.05	147.70	131.08	132.66	142.99	125.61
80.59	87.62	75.15	76.85	82.75	67.81
187.33	193.35	175.51	189.67	197.60	183.01
185.61	190.41	173.94	169.67	180.02	160.77
300.00	300.00	300.00	300.00	300.00	300.00
2914.82	2973.72	2876.31	2940.77	2968.72	2907.56
2914.56	2973.72	2873.74	2942.22	2967.50	2911.22
2875.67	2932.39	2838.28	2900.41	2923.63	2871.07
2738.98	2795.01	2708.70	2761.26	2782.56	2733.73
2649.25	2703.73	2621.23	2666.38	2684.96	2639.27
2583.49	2639.09	2556.60	2598.80	2617.48	2572.53
2584.02	2640.00	2556.60	2599.65	2617.48	2573.44
2555.52	2613.73	2529.40	2571.02	2589.37	2543.41
2552.67	2609.97	2525.65	2568.24	2586.54	2540.67
2340.83	2403.57	2315.38	2354.34	2371.78	2328.57
2345.83	2409.38	2320.29	2359.54	2376.60	2333.48
2304.58	2365.98	2280.01	2317.09	2334.03	2297.04
2270.43	2297.97	2246.99	2289.17	2305.81	2265.01
596.23	603.00	588.25	598.93	605.51	590.74
593.99	600.80	586.20	596.79	603.19	588.81
590.48	596.50	583.25	593.42	599.26	586.70
591.37	598.26	584.25	594.14	600.99	587.87
555.80	562.25	548.26	558.40	564.74	550.75
554.64	561.00	546.99	557.31	564.01	549.50
542.02	547.99	534.99	544.61	550.00	538.01
551.05	557.51	543.50	553.61	560.00	545.74
6.73	6.74	6.72	6.74	6.75	6.73
6.74	7.08	6.39	6.71	7.04	6.37
368.97	378.41	360.09	355.73	365.10	350.10
88.39	90.27	85.55	87.70	90.20	85.38
74.98	99.59	53.45	99.86	100.00	99.48
92.90	92.90	92.90	92.90	92.90	92.90
63.37	64.53	60.95	61.46	62.43	60.30
63.17	64.90	60.90	61.27	62.37	59.85
79.80	81.65	77.25	79.40	81.40	77.28
81.52	83.15	79.05	81.02	82.48	79.32
12.10	12.63	11.47	11.62	12.07	11.12
12.70	13.13	12.13	12.18	12.54	11.89
237.30	240.06	229.32	231.27	236.00	228.02
226.93	233.39	218.58	222.69	226.72	218.58
2.43	5.61	1.86	2.49	3.08	2.06
2.34	4.09	1.97	2.62	2.95	2.30
2.38	4.00	2.05	2.56	2.85	2.26
0.45	0.47	0.43	0.43	0.45	0.41
7839962	8192206	7711814	7577249	7727470	7410230
5018764	5218116	4804193	4674165	4868740	4494644
2821282	2973968	2720054	2903302	3043794	2811854
152.16	156.34	146.57	148.21	156.90	93.05
133.58	139.56	131.42	128.71	131.21	125.92

6705.22	6952.79	6441.79	6842.60	6972.66	6611.84
6717.06	6975.43	6438.15	6861.23	6989.53	6630.85
21.11	43.00	7.87	16.69	24.87	0.00
20.19	35.98	9.95	21.32	31.74	11.60
6737.80	6992.95	6478.53	6877.52	7000.00	6646.44
6754.44	6833.80	6686.82	6810.12	6856.44	6737.45
6738.29	6884.64	6623.16	6881.50	6994.02	6782.74
7.77	10.00	6.30	9.78	11.85	7.75
3343.55	3396.95	3284.65	3401.54	3442.12	3354.23
3309.57	3367.17	3241.31	3365.31	3415.88	3322.98
0.00	0.00	0.00	0.00	0.00	0.00
2381.33	2471.27	2261.30	2435.30	2486.28	2345.04
2248.94	2338.69	2162.54	2289.58	2358.71	2222.48
2268.13	2368.72	2183.78	2316.97	2381.30	2230.05
5530525	5649001	5425752	5636547	5745098	5551927
5532766	5649782	5426924	5637598	5746855	5552904
-0.49	0.81	-0.98	-0.48	0.11	-1.02
-0.52	-0.13	-0.95	-0.50	0.10	-0.80
-0.52	-0.13	-0.95	-0.50	0.10	-0.80
-0.56	-0.17	-0.99	-0.55	0.05	-0.85
-0.73	-0.33	-1.16	-0 73	-0.14	-1.01
-1.79	-1.30	-2.22	-1.80	-1.27	-2.01
-3.54	-2.93	-4.02	-3.51	-2.99	-3.78
-3.04	-2.44	-3.47	-2.98	-2.51	-3.18
-3.33	-2.70	-3.76	-3.25	-2.80	-3.51
3.67	4.86	3.19	3.43	4.07	2.87
4.22	5.00	3.73	3.97	4.41	3.53
-0.49	0.81	-0.98	-0.48	0.11	-1.02
-0.53	1.01	-0.75	-0.50	-0.15	-0.77
-1.22	0.26	-1.73	-1.21	-0.47	-1.84
-3 54	-1.97	-4.21	-3.51	-2.72	-4.07
-1.86	-0.30	-2.46	-1.85	-1.10	-2.47
-2.92	-1.34	-3.53	-2.86	-2.08	-3.43
-3.33	-1.71	-4.07	-3.25	-2.51	-3.76
-4.79	-3.17	-5.49	-4.66	-3.82	-5.22
-4.75	-3.11	-5.51	-4.63	-3.95	-5.14
-24.11	-21.19	-25.87	-23.05	-21.96	-24.46
5.32	5.91	4.38	5.15	5.40	4.65
5.14	6.17	4.51	5.05	5.48	4.43
5.43	6.08	4.64	5.03	5.53	4.42
5.21	6.26	4.18	5.10	5.77	4.50
8.00	9.37	7.16	7.56	8.47	6.99
8.30	9.22	7.57	7.82	8.37	7.19
7.91	8.85	7.10	7.43	8.01	6.77
7392.68	7525.04	7277.84	7426.85	7522.84	7286.90
3271.90	3342.08	3217.87	3348.09	3400.52	3299.36
543.66	575.03	511.06	558.20	580.34	533.59
806.97	880.40	754.66	824.99	868.56	783.29
395.71	426.47	372.26	394.78	416.27	359.57
567.64	585.65	521.56	530.02	562.40	499.47
808.35	852.81	739.16	754.50	784.57	725.79
282.02	293.95	269.40	269.38	280.10	255.93
622.87	645.71	591.81	651.25	689.72	615.92

	Tag not found:	Tag not found: -5		Tag not found:	Tag not found: -5
86.32	87.74	84.49	90.28	92.22	88.20
89.26	89.36	89.07	89.45	89.61	89.33
0.79	0.83	0.77	0.82	0.91	0.79
0.85	0.90	0.82	0.84	0.89	0.82
0.74	0.79	0.68	0.77	0.83	0.75
0.78	0.87	0.73	0.81	0.86	0.75
0.62	0.72	0.57	0.64	0.78	0.59
0.85	0.90	0.83	0.88	0.91	0.85
0.83	0.91	0.78	0.77	0.83	0.71
0.87	0.93	0.83	0.89	0.93	0.85
3704	3759.64	3598.13	3793	3862.67	3723.01
2233	2273.87	2160.22	2245	2275.70	2196.48
1522	1671.32	1450.97	1520	1656.06	1475.75
368.97	378.41	360.09	355.73	365.10	350.10
53.41	56.03	51.05	50.86	52.84	48.94
54.26	56.19	52.04	51.71	53.70	49.86
50.68	52.68	48.53	48.17	50.54	46.24
0.10	0.10	0.10	51.64	53.86	49.95
54.05	56.24	51.77	51.48	53.70	49.23
52.99	59.04	46.38	50.45	53.43	49.04
53.94	57.00	51.08	51.35	53.89	49.21
49.91	52.26	47.26	0.15	0.15	0.14
78.50	79.40	77.87	75.55	75.95	75.15
68.80	69.75	68.00	66.49	67.07	65.77
71.06	72.25	70.20	69.13	70.00	68.00
0.00	0.00	0.00	70.62	73.13	68.15
71.57	72.15	70.53	69.10	72.20	66.33
76.54	81.12	71.37	73.01	77.40	68.10
75.37	76.27	74.58	70.72	71.24	70.20
79.02	79.70	77.22	0.00	0.00	0.00
307.24	310.81	301.20	281.18	282.71	279.10
318.03	327.61	305.94	290.24	293.54	287.42
295.75	303.90	290.56	273.68	277.37	270.92
100.84	103.86	93.01	304.72	311.28	297.31
308.57	316.46	301.86	292.85	302.49	286.48
332.33	341.27	320.70	300.60	307.36	294.80
314.99	325.57	307.24	283.21	287.27	280.51
288.24	299.51	279.89	106.31	111.81	102.61
150.62	151.40	150.00	150.82	150.95	150.46
153.60	154.10	152.80	153.53	153.75	153.15
150.31	150.60	150.15	150.15	150.15	150.15
89.74	92.20	86.11	149.74	150.15	149.20
151.08	151.25	150.80	151.09	151.55	150.60
148.72	149.35	147.65	148.86	149.35	148.25
150.03	150.95	149.35	150.08	150.45	149.70
150.19	151.40	148.90	107.40	108.82	106.80
3668.01	3698.29	3620.47	3653 25	3667.77	3642.71
3588.69	3593.19	3534.20	3576.64	3641.22	3544.11

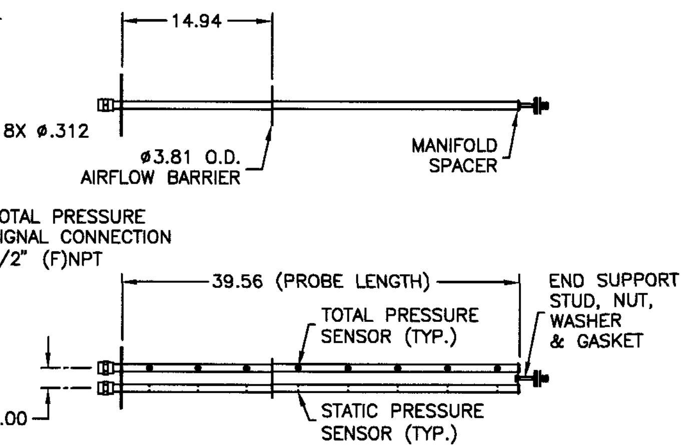
3756.89	3770.81	3709.99	3698.02	3709.51	3694.04
346.94	365.01	329.07	3459.42	3480.66	3438.18
3634.93	3641.35	3564.30	3601.34	3653.28	3575.24
3598.63	3608.24	3567.23	3571.72	3667.45	3523.24
3891.89	3898.62	3861.44	3836.18	3843.17	3833.43
4047.68	4189.45	3911.78	0.00	0.00	0.00
79.15	82.30	76.55	74.66	77.10	72.43
78.99	82.17	76.23	74.56	77.00	72.10
73.99	77.50	71.22	69.48	71.93	67.00
56.49	57.13	40.75	74.73	77.15	72.43
79.64	82.20	76.88	75.07	77.53	72.80
79.02	81.80	76.25	74.54	77.00	72.10
79.16	82.27	76.25	74.68	77.13	72.35
72.43	75.40	69.65	96.30	96.30	96.30
92.70	93.05	91.92	91.25	91.85	90.70
91.07	91.88	90.35	89.27	89.87	88.65
94.85	95.85	93.43	93.09	94.45	92.32
8.90	9.50	8.10	85.86	88.95	82.48
91.81	92.28	91.15	89.84	90.55	89.28
90.80	91.60	89.95	89.04	90.15	88.35
98.11	98.38	97.42	96.49	97.30	96.12
99.73	100.00	99.30	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
5.69	5.69	5.69	5.69	5.69	5.69
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
6.60	6.60	6.60	6.60	6.60	6.60
14.07	14.07	14.07	7.47	7.47	7.47
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
-4.00	-4.00	-4.00	-4.00	-4.00	-4.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
-5.00	-5.00	-5.00	-2.90	-2.90	-2.90
0.30	1.99	-1.74	0.03	1.63	-1.47
5.75	6.20	5.06	5.02	5.55	4.54
4.42	4.58	4.27	4.53	4.67	4.39
2.43	5.61	1.86	2.49	3.08	2.06
2.34	4.09	1.97	2.62	2.95	2.30
2.38	4.00	2.05	2.56	2.85	2.26
74.98	99.59	53.45	99.86	100.00	99.48
92.90	92.90	92.90	92.90	92.90	92.90

REV	DESCRIPTION	DATE	DWN	APV
1	CERTIFIED CORRECT	12/29/03	SEL	AEC



OFA DUCT – INDIVIDUAL PORT

PER BBP INC. DWG 100210-7237120-00
ID#: 100210-72371207



VOLU-probe/1SS

QUANTITY: 16

NOTES:

1. TYPICAL OF 16 INSTALLATIONS.

PROJECT:

INTERMOUNTAIN POWER UNIT 2
DELTA, UT
P.O. #434424
AMC W.O. #50600

FEATURE	MATERIAL
END SUPPORT STUD, NUT, WASHER	ø5/16-18, TYPE 316 SS
GASKETS	HIGH TEMP. CERAMIC FIBER
AIRFLOW BARRIER & MAN. SPACER	14 GA. TYPE 316 SS
T.P. & S.P. SIGNAL CONNECTIONS	1/2" FNPT, 316 SS
T.P. & S.P. SENSOR MANIFOLDS	ø.75 O.D. TUBE, 316 SS
MOUNTING PLATE	10 GA. TYPE 316 SS

CERTIFIED CORRECT

CHECKED BY: SEL DATE: 12/29/03

APPROVED BY: AEC DATE: 12/29/03

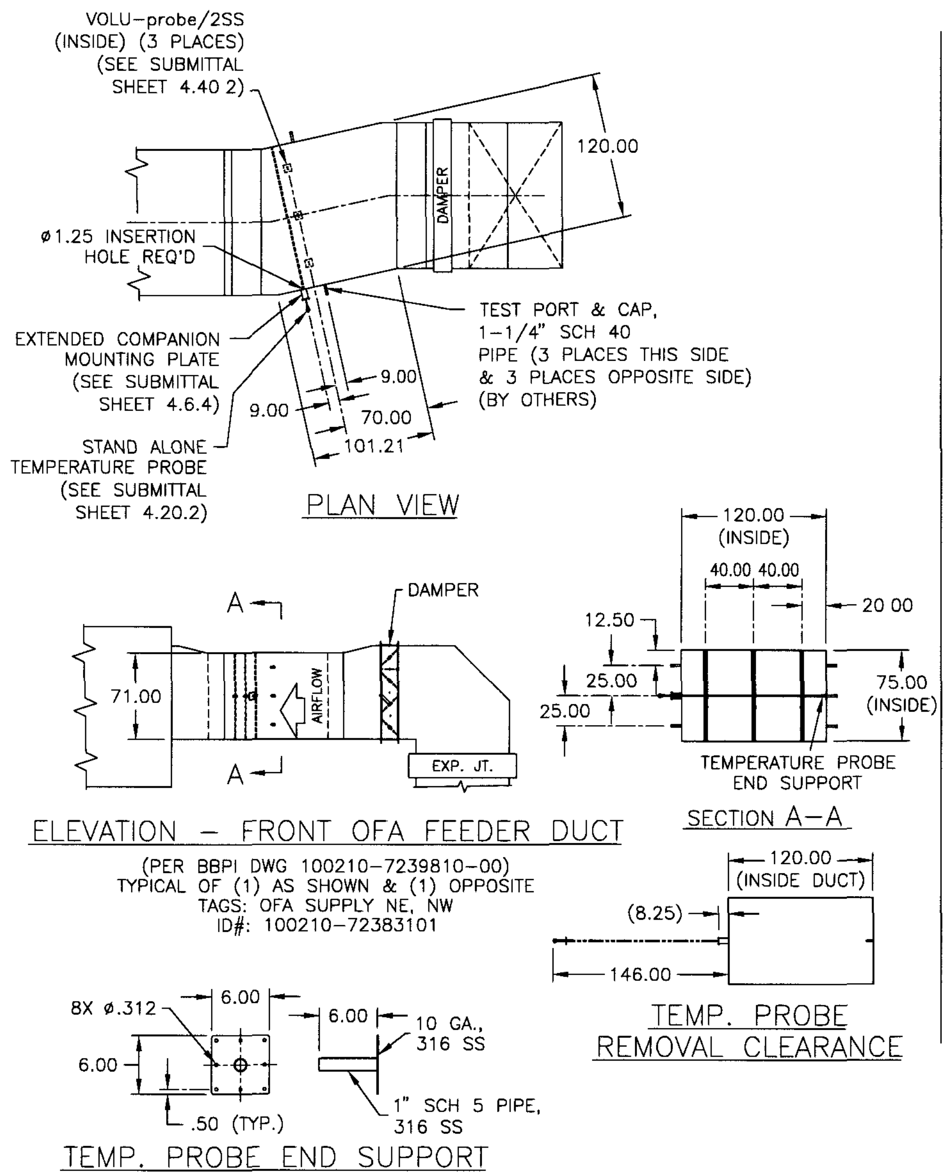
AIR MONITOR CORPORATION
P.O. Box 6358
Santa Rosa, CA. 95406

AIR MONITOR CORPORATION
P.O. BOX 6358 SANTA ROSA CA 95406
TELEPHONE (707) 544-2706

VOLU-probe/1SS
EQUIPMENT LOCATION – OFA PORTS

CAD PLOT	FORMAT	DWG NO.	REV
12/30/03 08:54:59	B	W50600AA	1
SCALE FACTOR: 24.00	SCALE: 1:24.00	DO NOT SCALE DRAWING	

IP7_036981



REV	DESCRIPTION	DATE	DWN	APV
1	CERTIFIED CORRECT	12/29/03	SEL	AEC
2	REVISED PER AS-BUILT	6-1-04	PN	SEL

PROJECT:
INTERMOUNTAIN POWER UNIT 2
DELTA, UT
P.O #434424
AMC W.O. #50600

CERTIFIED CORRECT
CHECKED BY SEL DATE 12/29/03
APPROVED BY AEC DATE 12/29/03
AIR MONITOR CORPORATION
P O Box 6358
Santa Rosa, CA 95406

AIR MONITOR CORPORATION
P O BOX 6358 SANTA ROSA CA 95406
TELEPHONE (707) 544-2706

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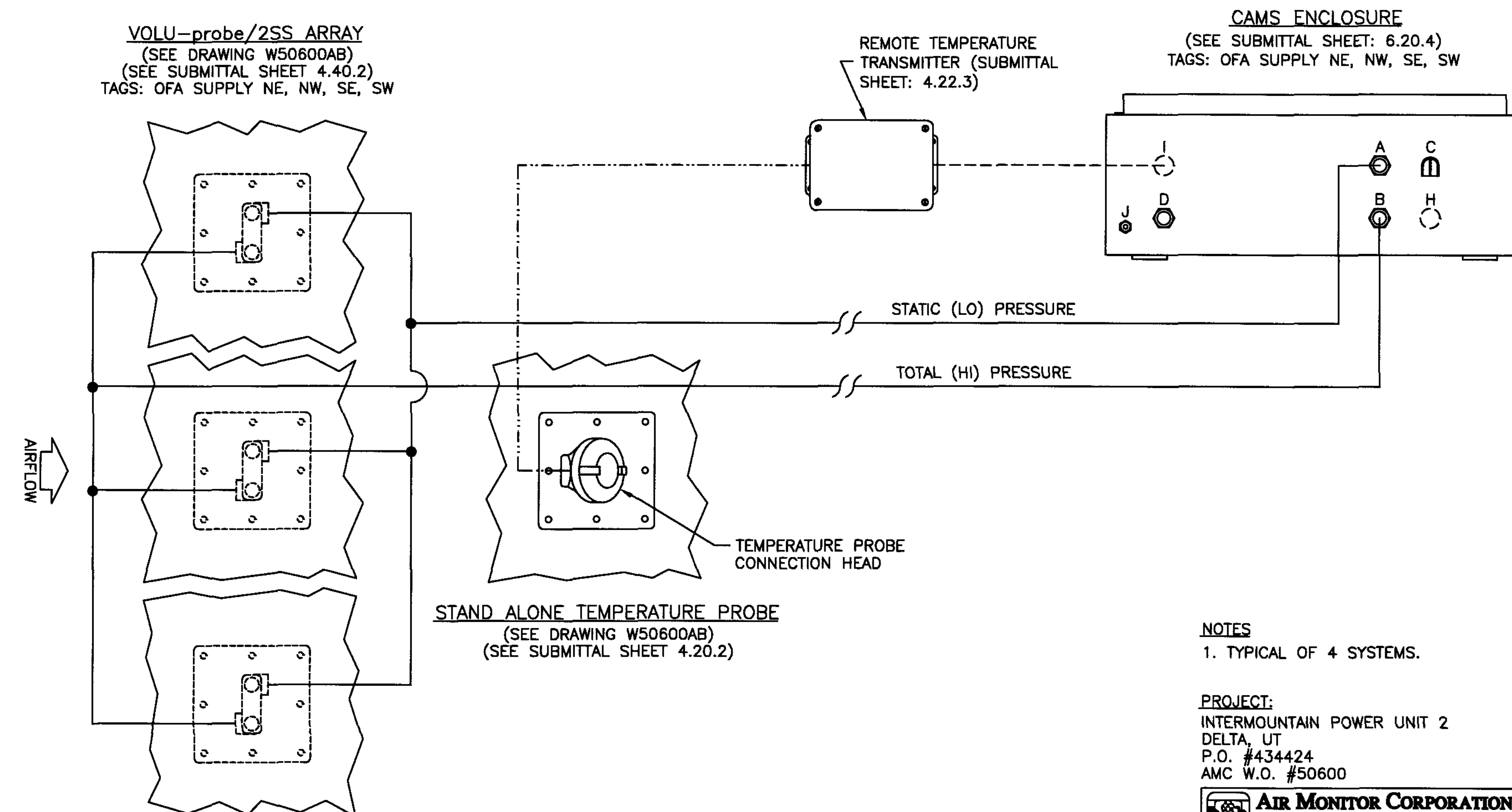
VOLU-probe/2SS
EQUIPMENT LOCATION

CAD PLOT		FORMAT	DWG NO	REV
06/07/04	13 05 21	B	W50600AB	2
SCALE FACTOR	100 00	SCALE	1:100.00	DO NOT SCALE DRAWING

REV	DESCRIPTION	DATE	DWN	APV
1	CERTIFIED CORRECT	12/29/03	SEL	AEC



LEGEND:

- THERMOCOUPLE EXTENSION WIRING (BY OTHERS)
- SIGNAL WIRING (BY OTHERS)
- SIGNAL TUBING, REF. SUBMITTAL SHEET 6.23.2 FOR TUBING SIZE (BY OTHERS)

NOTES

1. TYPICAL OF 4 SYSTEMS.

PROJECT:
INTERMOUNTAIN POWER UNIT 2
DELTA, UT
P.O. #434424
AMC W.O. #50600

CERTIFIED CORRECT
CHECKED BY: SEL DATE: 12/29/03
APPROVED BY: AEC DATE: 12/29/03
AIR MONITOR CORPORATION
P.O. Box 6358
Santa Rosa, CA 95406

AIR MONITOR CORPORATION
P.O. BOX 6358 SANTA ROSA CA 95406
TELEPHONE (707) 544-2706

TUBING & WIRING
DIAGRAM – OFA FEEDER DUCTS

CAD PLOT	FORMAT	DWG NO.	REV
12/30/03 09:05:47	B	W50600AC	1
SCALE FACTOR: 5.00	SCALE: 1:5.00	DO NOT SCALE DRAWING	

IP7_036983

VOLU-probe / 1SS – INDUSTRIAL
EXTERNALLY MOUNTED
STAINLESS STEEL AIRFLOW TRAVERSE PROBE

STANDARD CONSTRUCTION

Probe.	½", ¾", or 1" tube sensing manifolds, threaded end support, washer and nut, mounting plate, signal connection fittings, and identification tag, all fabricated of Type 316 stainless steel Neoprene gaskets included.
Mounting.	External duct mounted Threaded end support for probes greater than 18" long.
Connection Fittings.	½" FPT stainless steel.
Operating Temperature.	Continuous operation to 900°F

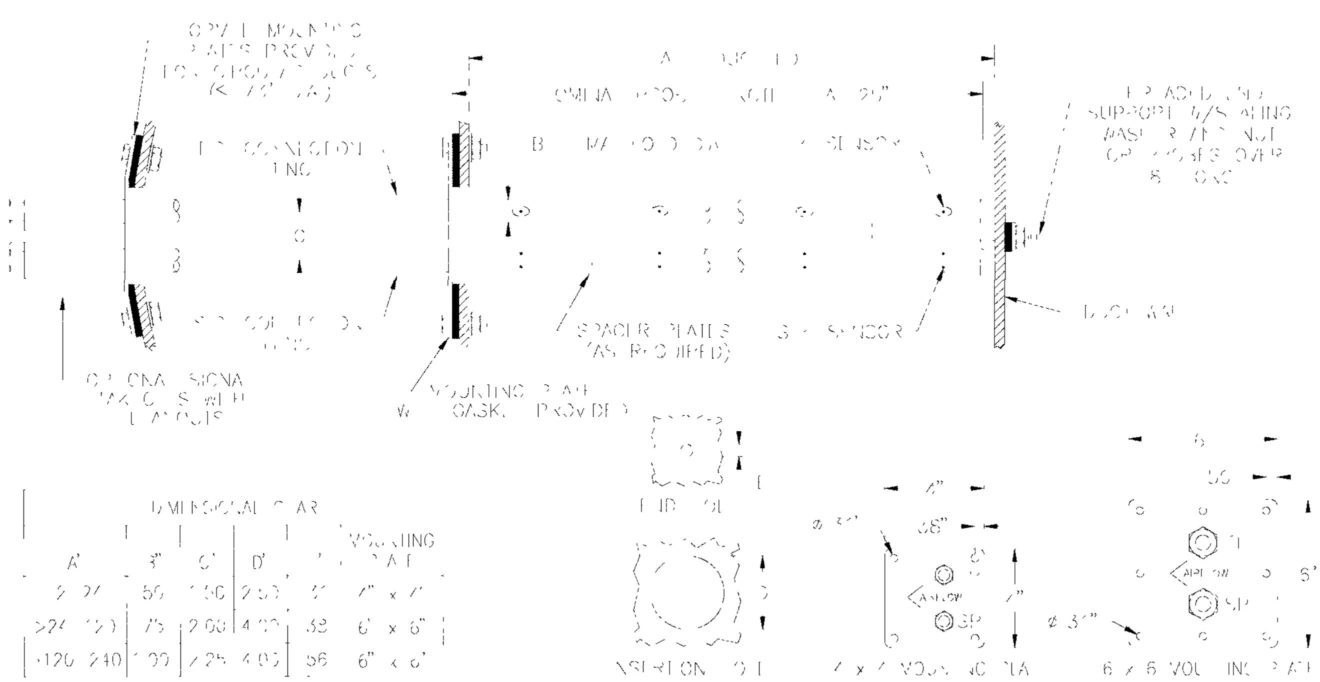
PERFORMANCE SPECIFICATIONS

Accuracy.	2-3%; dependent upon quantity and placement of probes to achieve traverse of ducted airflow
Outputs.	Individually averaged signals of total and static pressure
Operating Velocity.	100-10,000 FPM.
Directional Sensitivity.	Not measurably affected by directional airflows and pitch and yaw angles up to 30°.
Traverse Pattern.	On an equal area basis for rectangular probes On an equal concentric area basis for circular probes.
Resistance.	Less than 0.1 times the velocity pressure head at probe operating velocity

OPTIONAL CONSTRUCTION

Connection Fitting.	Signal Connection.	High Temperature Gaskets.
❑ ¼" Compression	❑ Cleanout	❑ Silicone, for continuous operation between 200°F and 400°F
❑ ½" Compression		❑ Fiber; for continuous operation between 400°F and 900°F

DIMENSIONAL SPECIFICATIONS



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AIR MONITOR CORPORATION

4.36.2

SUB-H001, Rev 14 (10/02)

IP7_036984

SUBMITTAL SHEET

VOLU-probe / 2SS – INDUSTRIAL
INTERNALLY MOUNTED
STAINLESS STEEL AIRFLOW TRAVERSE PROBE

STANDARD CONSTRUCTION

Probe.	½", ¾" or 1" tube sensing manifolds, mounting plates, signal connection fittings, and identification tag, all fabricated of Type 316 stainless steel.
Mounting.	Internal duct mounted. Dual end mounting plates.
Connection Fittings.	½" FPT stainless steel.
Operating Temperature.	Continuous operation to 900°F.

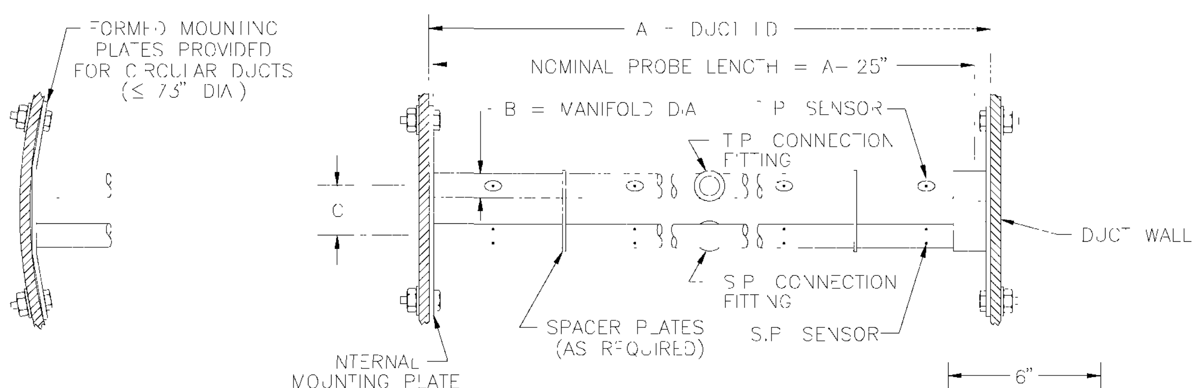
PERFORMANCE SPECIFICATIONS

Accuracy.	2-3%; dependent upon quantity and placement of probes to achieve traverse of ducted airflow.
Outputs.	Individually averaged signals of total and static pressure.
Operating Velocity.	100-10,000 FPM
Directional Sensitivity.	Not measurably affected by directional airflows with pitch and yaw angles up to 30°
Traverse Pattern.	On an equal area basis for rectangular probes. On an equal concentric area basis for circular probes.
Resistance.	Less than 0.1 times the velocity pressure head at probe operating velocity

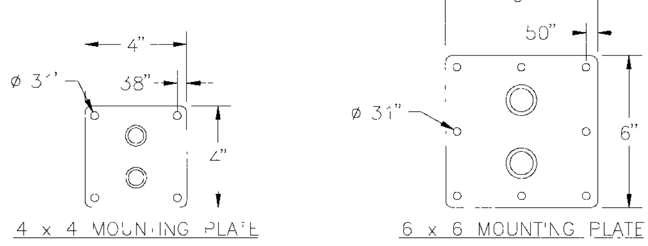
CONNECTION FITTINGS.

- ❑ ¼" Compression
- ❑ ½" Compression

DIMENSIONAL SPECIFICATIONS



DIMENSIONAL CHART			
A"	B"	C"	MOUNTING PLATE
12-24	.50	1.50	4" x 4"
>24-120	.75	2.00	6" x 6"
>120-240	1.00	2.25	6" x 6"



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AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: **Revere controls**
WORK ORDER: ______ *REV:* ______
TAG(S): ______

Given Information:

Fluid:	**AIR**		% H_2O (by volume):	**0.00**	(%)
Standard Temperature (T_{std}):	**68**	(deg. F)			
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)			
Air Temperature (T):	**250**	(deg. F)	Maximum Flow:	**10,000**	(SCFM)
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)		**Wet**	(Wet/Dry)
Actual Barometric Pressure (P_{bar}):	**24.000**	(in. Hg)			
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)			
Duct Shape:	**CIRC**		Square Root Extraction? (Yes/No)	**Yes**	
Duct Diameter:	**13.500**	(in.)	Output:	**4-20 mADC**	

Calculations:

Duct Area (A_s):	0.994	(ft^2)
Maximum Actual Velocity:	16,865	(AFPM)
Absolute Stack/Duct Pressure (P_s):	24.000	(in. Hg)
Dry Mole Fraction of Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.04482	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.1058	5.60	1,676	1,000	1,000	4,508	4,508
20	0.4234	7.20	3,353	2,000	2,000	9,016	9,016
30	0.9525	8.80	5,029	3,000	3,000	13,523	13,523
40	1.6937	10.40	6,706	4,000	4,000	18,031	18,031
50	2.6460	12.00	8,382	5,000	5,000	22,539	22,539
60	3.8107	13.60	10,059	6,000	6,000	27,047	27,047
70	5.1864	15.20	11,735	7,000	7,000	31,555	31,555
80	6.7746	16.80	13,412	8,000	8,000	36,062	36,062
90	8.5736	18.40	15,088	9,000	9,000	40,570	40,570
100	10.5841	20.00	16,764	10,000	10,000	45,078	45,078

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 SCFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 SCFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

0	0.0000	4.00	0	0	0	0	0

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: Interstate Paper
WORK ORDER: ____________ *REV:* ____________
TAG(S): ____________

Given Information:

Fluid:	AIR		% H_2O (by volume):		
Standard Temperature (T_{std}):	68	(deg. F)		0.00	(%, by volume)
Standard Barometric Pressure (P_{std}):	29.921	(in. Hg)			
Air Temperature (T):	110	**(deg. F)**	**Maximum Flow:**		
Stack/Duct Pressure (P_g):	0.00	(in. w.c.)		200,000	(lb/hr)
Actual Barometric Pressure (P_{bar}):	29.921	**(in. Hg)**		Wet	(Wet/Dry)
Air Density at Standard Conditions, DRY:	0.07513	(lbs/ft³)			
Duct Shape:	RECT		Square Root Extraction? (Yes/No)		
Duct Height:	39.000	**(in.)**		Yes	
Duct Width:	49.000	**(in.)**			
			Output:	4-20 mADC	

Calculations:

Duct Area (A_s):	13.271	(ft^2)
Maximum Actual Velocity:	3,609	(AFPM)
Absolute Duct Pressure (P_s):	29.921	(in. Hg)
Dry Mole Fraction of Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.06959	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.0075	5.60	4,790	4,437	4,437	20,000	20,000
20	0.0301	7.20	9,580	8,874	8,874	40,000	40,000
30	0.0677	8.80	14,369	13,310	13,310	60,000	60,000
40	0.1204	10.40	19,159	17,747	17,747	80,000	80,000
50	0.1882	12.00	23,949	22,184	22,184	100,000	100,000
60	0.2710	13.60	28,739	26,621	26,621	120,000	120,000
70	0.3688	15.20	33,527	31,057	31,057	140,000	140,000
80	0.4818	16.80	38,317	35,494	35,494	160,000	160,000
90	0.6097	18.40	43,107	39,931	39,931	180,000	180,000
100	0.7528	20.00	47,897	44,368	44,368	200,000	200,000

Transmitter:	CAMM	Power (voltage/type):	24VAC
Flow Element:	VOLU-probe/SS w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0-200,000 lbs/hr	Square Root:	ON
Temperature Range:	0 to 110deg.	Density Compensation:	ON
Pressure Comp. Range:	?		

Temperature Sensor: Single-Pt. Type "E" T/C Probe with panel-mounted 4-20mADC temperature transmitter.

Display Line #1:	0-200,000 lbs/hr	(FLOW)
Display Line #2:	0 to 110deg.	(TEMPERATURE)
Display Line #3:	?	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to .7528 IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: __________
WORK ORDER: __________ REV: __________
TAG(S): __________

Given Information:

Fluid:	**AIR**	
Standard Temperature (T_{std}):	**68**	(deg. F)
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)
Air Temperature (T):	**150**	(deg. F)
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)
Actual Barometric Pressure (P_{bar}):	**29.921**	(in. Hg)
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)
Duct Shape:	**CIRC**	
Duct Diameter:	**50.897**	(in.)

% H_2O (by volume): **5.00** (%)

Maximum Volumetric Flow: **40,000** (ACFM)

Square Root Extraction? (Yes/No) **Yes**

Output: **4-20 mADC**

Calculations:

Stack/Duct Area (A_s):	14.129	(ft^2)
Maximum Actual Velocity:	2,831	(AFPM)
Absolute Stack/Duct Pressure (P_s):	29.921	(in. Hg)
Dry Mole Fraction of Stack/Duct (Mfd):	0.950	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.417	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07371	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.06380	(lbs/ft^3)

Gain: 3
% Bias: -3
K-Factor: ON

% DP (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0042	4.00	0	0	0	0	0
10	0.0057	5.60	4,000	3,289	3,462	14,826	15,311
20	0.0099	7.20	8,000	6,578	6,924	29,652	30,622
30	0.0170	8.80	12,000	9,868	10,387	44,483	45,937
40	0.0269	10.40	16,000	13,157	13,849	59,309	61,249
50	0.0396	12.00	20,000	16,446	17,312	74,135	76,564
60	0.0552	13.60	24,000	19,735	20,774	88,961	91,875
70	0.0736	15.20	28,000	23,024	24,236	103,788	107,186
80	0.0948	16.80	32,000	26,313	27,698	118,614	122,497
90	0.1189	18.40	36,000	29,603	31,161	133,444	137,812
100	0.1458	20.00	40,000	32,892	34,623	148,271	153,123

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 ACFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 ACFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: ____________________

WORK ORDER: __________ *REV:* __________

TAG(S): ____________________

Given Information:

Fluid:	**AIR**	
Standard Temperature (T_{std}):	**68**	(deg. F)
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)
Air Temperature (T):	**165**	(deg. F)
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)
Actual Barometric Pressure (P_{bar}):	**24.000**	(in. Hg)
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)
Duct Shape:	**CIRC**	
Duct Diameter:	**13.500**	(in.)

% H_2O (by volume): **0.00** (%)

Maximum Differential Pressure: **0.6700** (inches w.c.)

Square Root Extraction? (Yes/No) **Yes**

Output (4-20,0-10,0-5): **4-20 mADC**

Calculations:

Stack/Duct Area (A_s):	0.994	(ft^2)
Maximum Actual Velocity:	3,981	(AFPM)
Absolute Stack/Duct Pressure (P_s):	24.000	(in. Hg)
Dry Mole Fraction of Stack/Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.05091	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.0067	5.60	396	268	268	1,208	1,208
20	0.0268	7.20	791	536	536	2,416	2,416
30	0.0603	8.80	1,187	804	804	3,624	3,624
40	0.1072	10.40	1,583	1,073	1,073	4,837	4,837
50	0.1675	12.00	1,979	1,341	1,341	6,045	6,045
60	0.2412	13.60	2,374	1,609	1,609	7,253	7,253
70	0.3283	15.20	2,770	1,877	1,877	8,461	8,461
80	0.4288	16.80	3,166	2,145	2,145	9,669	9,669
90	0.5427	18.40	3,562	2,413	2,413	10,877	10,877
100	0.6700	20.00	3,957	2,682	2,682	12,090	12,090

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 ACFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 ACFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

Conversions/Calculations

(Inputs are boxed; outputs are yellow.)

Absolute Pressure

Elevation:	4500	ft MSL
Std. Barometer:	25.364	in. Hg
Static Pressure:	0.0	in. w.c.
Absolute Pressure:	25.364	in. Hg

Pressure

Inches H2O:	83
Inches Hg	6.105
PSI:	2.999
PSI:	1
Inches H2O:	27.681
Inches Hg:	2.036

Equivalent Duct Diameter

Height:	26
Width:	12
D:	16.42

Flow

CFM:	35000
m3/hr:	59,465
L/sec:	16,518
lb/hr:	100000
kg/hr:	229,570
T/hr (metric):	45.360

Density

lbs/ft3:	0.07513
kg/m3:	1.203
g/cm3:	0.001203
kg/m3:	1.203
lbs/ft3:	0.07507
g/cm3:	0.001203

Temperature	
Deg. F:	$\boxed{32}$
Deg. C:	0.00
Deg. C:	$\boxed{100.0}$
Deg. F:	212

Dimensions	
Inches:	$\boxed{39.37}$
Feet:	3.28
Meters:	1.000
Millimeters:	1000
Millimeters:	$\boxed{25.4}$
Meters:	0.025
Inches:	1.000
Feet:	0.083

AIR MONITOR CORPORATION

K-FACTOR FLOW WORKSHEET

PROJECT: ______________________

WORK ORDER: ______________ *REV:* ________

TAG(S): ______________________

Station: CA Station w/Temp Probe
Transmitter Model: MASS-tron II
Traverse Probe Type:
Test Technician:

Given:

Point #	*% Flow*	*Measured*	*Reference*
Low	50	116,570	143,149
Mid	71	179,780	219,878
*High**	100	237,770	286,216

Transmitter Full Scale (Calibrated): 387,000

Engineering Units: SCFM

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain and Bias applied prior to square root)

Point	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Correceted Flow*	*Eng. Units*	*% Error*
Low	116,570	143,149	SCFM	-18.57	143,941	SCFM	0.55
Mid	179,780	219,878	SCFM	-18.24	218,655	SCFM	-0.56
High	237,770	286,216	SCFM	-16.93	287,799	SCFM	0.55

Uncorrected Full Scale = 387,000 SCFM

Corrected Full Scale, Using Original Max DP = 466,547 SCFM

Gain = 1.44622

% Bias = 0.71236

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

				(Gain 1) 1.50190		*(Gain 2)* 1.47214		*(Gain 3)* 1.47807	
Point	*Measured*	*Reference*	*% Error*	*M1*	*% Error*	*M2*	*% Error*	*M3*	*% Error*
Low	116,570	143,149	-18.6	142,859	-0.2	141,437	-1.2	141,721	-1.0
Mid	179,780	219,878	-18.2	220,324	0.2	218,130	-0.8	218,569	-0.6
High	237,770	286,216	-16.9	291,392	1.8	288,491	0.8	289,071	1.0

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng. Units*	*% Error*
1	116,570	143,149	SCFM	-18.57	142,859	SCFM	-0.20
2	179,780	219,878	SCFM	-18.24	220,324	SCFM	0.20

Uncorrected Full Scale = 387,000 SCFM

Corrected Full Scale = 474,276 SCFM
(using max. DP)

Gain = 1.50190

* "High" value not used in 2-pt.correction.

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: **Revere controls**

WORK ORDER: ____________ *REV:* ____________

TAG(S): ____________

Given Information:

Fluid:	**AIR**		% H_2O (by volume):		
Standard Temperature (T_{std}):	**68**	(deg. F)	**0.00**	(%)	
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)			
Air Temperature (T):	**250**	(deg. F)	Maximum Flow:		
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)	**10,000**	(SCFM)	
Actual Barometric Pressure (P_{bar}):	**24.000**	(in. Hg)	**Wet**	(Wet/Dry)	
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)			
Duct Shape:	**CIRC**		Square Root Extraction? (Yes/No)		
Duct Diameter:	**13.500**	(in.)	**Yes**		

Output: **4-20 mADC**

Calculations:

Duct Area (A_s):	0.994	(ft^2)
Maximum Actual Velocity:	16,865	(AFPM)
Absolute Stack/Duct Pressure (P_s):	24.000	(in. Hg)
Dry Mole Fraction of Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.04482	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.1058	5.60	1,676	1,000	1,000	4,508	4,508
20	0.4234	7.20	3,353	2,000	2,000	9,016	9,016
30	0.9525	8.80	5,029	3,000	3,000	13,523	13,523
40	1.6937	10.40	6,706	4,000	4,000	18,031	18,031
50	2.6460	12.00	8,382	5,000	5,000	22,539	22,539
60	3.8107	13.60	10,059	6,000	6,000	27,047	27,047
70	5.1864	15.20	11,735	7,000	7,000	31,555	31,555
80	6.7746	16.80	13,412	8,000	8,000	36,062	36,062
90	8.5736	18.40	15,088	9,000	9,000	40,570	40,570
100	10.5841	20.00	16,764	10,000	10,000	45,078	45,078

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 SCFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 SCFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

0	0.0000	4.00	0	0	0	0	0

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: **Interstate Paper**
WORK ORDER: ______ *REV:* ______
TAG(S): ______

Given Information:

Fluid:	**AIR**	
Standard Temperature (T_{std}):	**68**	(deg. F)
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)
Air Temperature (T):	**110**	**(deg. F)**
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)
Actual Barometric Pressure (P_{bar}):	**29.921**	**(in. Hg)**
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)
Duct Shape:	**RECT**	
Duct Height:	**39.000**	**(in.)**
Duct Width:	**49.000**	**(in.)**

% H_2O (by volume): **0.00** (%, by volume)

Maximum Flow: **200,000** (lb/hr)
Wet (Wet/Dry)

Square Root Extraction? (Yes/No) **Yes**

Output: **4-20 mADC**

Calculations:

Duct Area (A_s):	13.271	(ft^2)
Maximum Actual Velocity:	3,609	(AFPM)
Absolute Duct Pressure (P_s):	29.921	(in. Hg)
Dry Mole Fraction of Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.06959	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.0075	5.60	4,790	4,437	4,437	20,000	20,000
20	0.0301	7.20	9,580	8,874	8,874	40,000	40,000
30	0.0677	8.80	14,369	13,310	13,310	60,000	60,000
40	0.1204	10.40	19,159	17,747	17,747	80,000	80,000
50	0.1882	12.00	23,949	22,184	22,184	100,000	100,000
60	0.2710	13.60	28,739	26,621	26,621	120,000	120,000
70	0.3688	15.20	33,527	31,057	31,057	140,000	140,000
80	0.4818	16.80	38,317	35,494	35,494	160,000	160,000
90	0.6097	18.40	43,107	39,931	39,931	180,000	180,000
100	0.7528	20.00	47,897	44,368	44,368	200,000	200,000

Transmitter:	CAMM	Power (voltage/type):	24VAC
Flow Element:	VOLU-probe/SS w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0-200,000 lbs/hr	Square Root:	ON
Temperature Range:	0 to 110deg.	Density Compensation:	ON
Pressure Comp. Range:	?		

Temperature Sensor: Single-Pt. Type "E" T/C Probe with panel-mounted 4-20mADC temperature transmitter.

Display Line #1:	0-200,000 lbs/hr	(FLOW)
Display Line #2:	0 to 110deg.	(TEMPERATURE)
Display Line #3:	?	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to .7528 IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: ______
WORK ORDER: ______ REV: ______
TAG(S): ______

Given Information:

Fluid:	**AIR**	
Standard Temperature (T_{std}):	**68**	(deg. F)
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)
Air Temperature (T):	**150**	(deg. F)
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)
Actual Barometric Pressure (P_{bar}):	**29.921**	(in. Hg)
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)
Duct Shape:	**CIRC**	
Duct Diameter:	**50.897**	(in.)

% H_2O (by volume): **5.00** (%)

Maximum Volumetric Flow: **40,000** (ACFM)

Square Root Extraction? (Yes/No): **Yes**

Output: **4-20 mADC**

Calculations:

Stack/Duct Area (A_s):	14.129	(ft^2)
Maximum Actual Velocity:	2,831	(AFPM)
Absolute Stack/Duct Pressure (P_s):	29.921	(in. Hg)
Dry Mole Fraction of Stack/Duct (Mfd):	0.950	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.417	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07371	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.06380	(lbs/ft^3)

Gain: 3
% Bias: -3
K-Factor: ON

% DP (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0042	4.00	0	0	0	0	0
10	0.0057	5.60	4,000	3,289	3,462	14,826	15,311
20	0.0099	7.20	8,000	6,578	6,924	29,652	30,622
30	0.0170	8.80	12,000	9,868	10,387	44,483	45,937
40	0.0269	10.40	16,000	13,157	13,849	59,309	61,249
50	0.0396	12.00	20,000	16,446	17,312	74,135	76,564
60	0.0552	13.60	24,000	19,735	20,774	88,961	91,875
70	0.0736	15.20	28,000	23,024	24,236	103,788	107,186
80	0.0948	16.80	32,000	26,313	27,698	118,614	122,497
90	0.1189	18.40	36,000	29,603	31,161	133,444	137,812
100	0.1458	20.00	40,000	32,892	34,623	148,271	153,123

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 ACFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 ACFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT:

WORK ORDER: *REV:*

TAG(S):

Given Information:

Fluid:	AIR	
Standard Temperature (T_{std}):	68	(deg. F)
Standard Barometric Pressure (P_{std}):	29.921	(in. Hg)
Air Temperature (T):	165	(deg. F)
Stack/Duct Pressure (P_g):	0.00	(in. w.c.)
Actual Barometric Pressure (P_{bar}):	24.000	(in. Hg)
Air Density at Standard Conditions, DRY:	0.07513	(lbs/ft^3)
Duct Shape:	CIRC	
Duct Diameter:	13.500	(in.)

% H_2O (by volume): 0.00 (%)

Maximum Differential Pressure: 0.6700 (inches w.c.)

Square Root Extraction? (Yes/No) Yes

Output (4-20,0-10,0-5): 4-20 mADC

Calculations:

Stack/Duct Area (A_s):	0.994	(ft^2)
Maximum Actual Velocity:	3,981	(AFPM)
Absolute Stack/Duct Pressure (P_s):	24.000	(in. Hg)
Dry Mole Fraction of Stack/Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.05091	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.0067	5.60	396	268	268	1,208	1,208
20	0.0268	7.20	791	536	536	2,416	2,416
30	0.0603	8.80	1,187	804	804	3,624	3,624
40	0.1072	10.40	1,583	1,073	1,073	4,837	4,837
50	0.1675	12.00	1,979	1,341	1,341	6,045	6,045
60	0.2412	13.60	2,374	1,609	1,609	7,253	7,253
70	0.3283	15.20	2,770	1,877	1,877	8,461	8,461
80	0.4288	16.80	3,166	2,145	2,145	9,669	9,669
90	0.5427	18.40	3,562	2,413	2,413	10,877	10,877
100	0.6700	20.00	3,957	2,682	2,682	12,090	12,090

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 ACFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 ACFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

Conversions/Calculations

(Inputs are boxed; outputs are yellow.)

Absolute Pressure

Elevation:	4500	ft MSL
Std. Barometer:	25.364	in. Hg
Static Pressure:	0.0	in. w.c.
Absolute Pressure:	25.364	in. Hg

Pressure

Inches H2O:	83
Inches Hg	6.105
PSI:	2.999
PSI:	1
Inches H2O:	27.681
Inches Hg:	2.036

Equivalent Duct Diameter

Height:	26
Width:	12
D:	16.42

Flow

CFM:	35000
m3/hr:	59,465
L/sec:	16,518
lb/hr:	100000
kg/hr:	229,570
T/hr (metric):	45.360

Density

lbs/ft3:	0.07513
kg/m3:	1.203
g/cm3:	0.001203
kg/m3:	1.203
lbs/ft3:	0.07507
g/cm3:	0.001203

Temperature

Deg. F:	$\boxed{32}$
Deg. C:	0.00
Deg. C:	$\boxed{100.0}$
Deg. F:	212

Dimensions

Inches:	$\boxed{39.37}$
Feet:	3.28
Meters:	1.000
Millimeters:	1000
Millimeters	$\boxed{25.4}$
Meters:	0.025
Inches:	1.000
Feet:	0.083

AIR MONITOR CORPORATION

K-FACTOR FLOW WORKSHEET

PROJECT: ____________________

WORK ORDER: ____________ *REV:* ______

TAG(S): ____________________

Station: CA Station w/Temp Probe

Transmitter Model: MASS-tron II

Traverse Probe Type:

Test Technician:

Given:

Point #	*% Flow*	*Measured*	*Reference*
Low	50	161,455	190,991
Mid	71	233,005	261,747
*High**	100	293,141	326,688

Transmitter Full Scale (Calibrated): 387,000

Engineering Units: SCFM

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain and Bias applied prior to square root)

Point	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Correceted Flow*	*Eng. Units*	*% Error*
Low	161,455	190,991	SCFM	-15.46	190,239	SCFM	-0.39
Mid	233,005	261,747	SCFM	-10.98	262,773	SCFM	0.39
High	293,141	326,688	SCFM	-10.27	325,402	SCFM	-0.39

Uncorrected Full Scale = 387,000 SCFM

Corrected Full Scale, Using Original Max DP = 424,509 SCFM

Gain = 1.16423

% Bias = 3.90072

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

				(Gain 1) 1.32797		*(Gain 2)* 1.25189		*(Gain 3)* 1.31714	
Point	*Measured*	*Reference*	*% Error*	*M1*	*% Error*	*M2*	*% Error*	*M3*	*% Error*
Low	161,455	190,991	-15.5	186,057	-2.6	180,649	-5.4	185,297	-3.0
Mid	233,005	261,747	-11.0	268,509	2.6	260,704	-0.4	267,412	2.2
High	293,141	326,688	-10.3	337,808	3.4	327,989	0.4	336,428	3.0

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng.Units*	*% Error*
1	161,455	190,991	SCFM	-15.46	186,057	SCFM	-2.58
2	233,005	261,747	SCFM	-10.98	268,509	SCFM	2.58

Uncorrected Full Scale = 387,000 SCFM

Corrected Full Scale = 445,969 SCFM
(using max. DP)

Gain = 1.32797

* "High" value not used in 2-pt.correction.

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		691				
AVERAGE PRESSURE IN. W.C. (Pg)		1.31				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.10	25.10	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	37.90	37.89	
ACTUAL STACK VOLUME (Q acfm) =	145,896	145,884	-0.01
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	56,137	56,132	-0.01
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	56,137	56,132	-0.01
FLOW IN LBS/HR (wet) =	253061	253038	-0.01
FLOW IN LBS/HR (dry) =	253061	253038	-0.01

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.028909
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037008

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.122	0.00	691	0.037	0	1.29	1.36	-0.005	0.000	1.29	1.37	0.000	-0.424	0.974	0.036	0.42
	2	0.121	-3.00	691	0.021	-0.002	1.39	1.47	-0.001	0 000	1.39	1.48	-0.095	-7.557	0.985	0.021	8 13
	3	0.126	-12.00	691	0.045	0	1.5	1.57	-0.005	0.000	1.50	1.58	0.000	-0.424	0.974	0.044	12.01
	4	0.127	-3.00	691	0.084	0	1.34	1.36	-0.005	0.000	1.34	1.36	0.000	-0 424	0.974	0.082	3.03
2	1	0.127	3.00	691	0.159	0.05	1.43	1.37	-0.010	-0.002	1.43	1.36	0.314	20.396	1.018	0.162	20.61
	2	0.122	7.00	691	0.184	0.05	1.44	1.36	-0.010	-0.002	1.44	1.35	0.272	19.339	1.012	0.186	20.52
	3	0.125	25.00	691	0.192	-0.043	1.61	1.53	0.001	0.000	1.61	1.52	-0.224	-14.920	1.004	0.193	28.87
	4	0.126	3.00	691	0.037	-0.004	1.58	1.66	-0.001	0.000	1.58	1.67	-0.108	-8.377	0.986	0.036	8.89
3	1	0.122	4.00	691	0.021	-0.006	1.34	1.43	0.000	0.000	1.34	1 45	-0.286	-18.519	1.019	0.021	18.93
	2	0.127	-2.00	691	0.041	-0.017	1.25	1.32	-0.003	0.000	1.25	1.33	-0.415	-27.100	1.087	0.045	27.17
	3	0.126	4.00	691	0.073	-0.025	1.35	1.38	-0.001	0.000	1.35	1.39	-0.342	-22.240	1.042	0.076	22.58
	4	0.123	8.00	691	0.126	-0.04	1.46	1.44	0.000	0.000	1.46	1.44	-0.317	-20.555	1 030	0.130	21.99
4	1	0.12	15.00	691	0.154	-0.046	1.39	1.34	0.000	0.000	1.39	1.33	-0.299	-19 336	1 023	0.158	24.29
	2	0.123	28.00	691	0.231	-0.048	1.31	1.18	0.001	0.000	1.31	1.16	-0.208	-14.033	1.001	0.231	31.06
	3	0.128	9.00	691	0.049	-0.006	1.12	1.18	0.000	0.000	1.12	1.19	-0 122	-9.257	0.988	0.048	12.88
	4	0.129	4.00	691	0.057	-0.005	1.15	1.2	-0.001	0.000	1.15	1.21	-0.088	-7.063	0.984	0.056	8.11
5	1	0.129	1.00	691	0.041	-0.007	1.06	1.13	0.000	0.000	1.06	1.14	-0.171	-12.015	0.995	0.041	12.06
	2	0.121	-1.00	691	0.066	0	1.2	1.24	-0.005	0.000	1.20	1.25	0.000	-0.424	0.974	0.064	1.09
	3	0.121	9.00	691	0.133	-0.012	1.14	1.12	-0.001	0 000	1.14	1.12	-0.090	-7.229	0.984	0.131	11.53
	4	0.126	10.00	691	0.161	-0.013	1.14	1.09	-0.001	0.000	1.14	1.08	-0.081	-6.594	0.983	0.158	11.96
6	1	0.124	25.00	691	0.232	-0.014	1.31	1.18	-0.002	0 000	1.31	1.16	-0.060	-5.165	0.980	0.227	25.49
	2	0.127	7.00	691	0.07	0.001	1.24	1.28	-0.005	0.000	1.24	1.29	0.014	0.797	0.973	0.068	7.05
	3	0.122	2.00	691	0.065	0.003	1.27	1.3	-0.007	0.000	1.27	1.31	0.046	3.612	0.973	0.063	4 13
	4	0.127	-5.00	691	0.052	-0.005	1.18	1.24	-0.001	0.000	1.18	1 25	-0.096	-7.616	0.985	0.051	9.10
7	1	0.124	-2.00	691	0.085	-0.002	1.2	1.22	-0.004	0.000	1.20	1 22	-0.024	-2.360	0.976	0.083	3.09
	2	0.122	-3.00	691	0.122	0.002	1.23	1.21	-0.006	-0.001	1.23	1.21	0.016	0.980	0.973	0.119	3.16
	3	0.118	5.00	691	0.167	0.008	1.26	1.19	-0.007	-0.001	1.26	1.18	0.048	3.769	0.973	0.162	6.26
	4	0.126	13.00	691	0.227	0.002	1.39	1.26	-0.005	-0.001	1.39	1.24	0.009	0.326	0.974	0.221	13.00
8	1	0.13	0.00	691	0.242	-0.02	1.44	1.3	-0.001	0.000	1.44	1.28	-0.083	-6.723	0.983	0.238	6.72
	2	0.122	-5.00	691	0.205	-0.02	1.42	1.31	-0.001	0.000	1.42	1.29	-0.098	-7.707	0.985	0.202	9.18
	3	0.125	5.00	691	0.208	-0.005	1.3	1.2	-0.004	-0.001	1.30	1.18	-0.024	-2.400	0.976	0.203	5.55
	4	0.122	-4.00	691	0.204	0.01	1.4	1.3	-0.007	-0.001	1.40	1 28	0.049	3.869	0.973	0.198	5.56
9	1	0.122	0.00	691	0.202	0.025	1.28	1.18	-0.010	-0.002	1.28	1.16	0.124	10 488	0.980	0.198	10.49
	2	0.122	0.00	691	0.171	0.026	1.33	1.26	-0.011	-0.002	1.33	1.25	0.152	12.774	0.985	0.169	12.77
	3	0.119	4.00	691	0.145	0.029	1.27	1.23	-0.011	-0.002	1.27	1 22	0.200	16.082	0.997	0.145	16.56
	4	0.121	-3.00	691	0.375	-0.026	1.65	1.36	-0.002	-0.001	1.65	1.31	-0.069	-5.806	0.981	0.368	6.53
	37	0.123	-2.00	691	0.367	-0.006	1.64	1.37	-0.004	-0.001	1.64	1.32	-0.016	-1.780	0.976	0.358	2.68
	38	0.131	5.00	691	0.339	0.022	1.64	1.4	-0.008	-0.003	1.64	1.36	0.065	5.299	0.973	0.330	7.28
	39	0.127	0.00	691	0.35	0.043	1.58	1.33	-0.010	-0.003	1.58	1.29	0.123	10.412	0.980	0.343	10.41
	40	0.125	0.00	691	0.303	0.057	1.7	1.5	-0.011	-0.003	1.70	1.46	0.188	15.340	0.994	0.301	15.34
	41	0.121	5.00	691	0.253	0.064	1.57	1.42	-0.010	-0.003	1.57	1.39	0.253	18.687	1.009	0.255	19.32
	42	0.121	4.00	691	0.128	0.076	1.45	1.44	0.070	0.011	1.44	1 44	0.594	49.137	1.218	0.156	49.26

-12.00

Avg. Duct Static = 1.31

Yaw Avg. = 3.81
Std. Dev. = 8.12

Average Temp.
691

Pitch Avg. = -1.07
Std. Dev. = 13.95

Result Angle Avg. = 13.22
Std. Dev. = 9.82

IP7_037009

12/23/2010

OFA NE BOTH DAMPERS OPEN 4-2-03

Traverse Point Velocity	Probes Point Velocity
20.42	37.57
15.31	37.41
22.02	38.17
30.73	38.33
40.52	38.33
43.47	37.57
41.35	38.02
20.29	38.16
14.88	37.57
20.21	38.33
27.39	38.18
35.93	37.72
38.92	37.26
44.32	37.74
23.08	38.49
25.22	38.64
21.25	38.65
27.28	37.42
38.14	37.43
41.88	38.20
46.31	37.89
27.87	38.34
26.98	37.57
24.04	38.34
30.95	37.88
37.02	37.58
43.11	36.96
49.28	38.19
52.11	38.79
47.72	37.57
48.26	38.04
47.70	37.57
47.07	37.58
43.07	37.58
39.20	37.11
64.83	37.42
64.30	37.73
61.29	38.93
61.96	38.34
56.91	38.02
51.27	37.41
27.72	37.41

Traverse	Probes
Avg. Velocity in ft/s	
37.90	37.89

12/23/2010

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		652				
AVERAGE PRESSURE IN. W.C. (Pg)		2.65				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.20	25.20	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	21.18	19.58	
ACTUAL STACK VOLUME (Q acfm) =	81,532	75,391	-7.53
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	32,614	30,158	-7.53
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	32,614	30,158	-7.53
FLOW IN LBS/HR (wet) =	147021	135950	-7.53
FLOW IN LBS/HR (dry) =	147021	135950	-7.53

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030054
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037012

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.033	-13.00	651	0.007	0.000	2.39	2.49	-0.005	0.000	2.39	2.51	0 000	-0.424	0.974	0.007	13.01
	2	0.032	0.00	651	0.023	0.000	2.43	2.51	-0.005	0.000	2.43	2.52	0.000	-0.424	0.974	0.022	0.42
	3	0.033	3.00	651	0.036	0.000	2.49	2.55	-0.005	0.000	2.49	2.56	0.000	-0.424	0.974	0.035	3.03
	4	0.031	-10.00	651	0.058	0.000	2.47	2.52	-0.005	0.000	2.47	2.53	0.000	-0 424	0.974	0.057	10.01
2	1	0.034	-5.00	651	0.063	0.000	2.61	2.65	-0.005	0.000	2.61	2.66	0.000	-0.424	0.974	0.061	5.02
	2	0.036	3.00	651	0.070	-0.054	2.53	2.57	0.000	0.000	2.53	2.58	-0.771	-19.073	1.022	0.072	19.30
	3	0.031	13.00	651	0.071	-0.025	2.63	2.67	-0.001	0.000	2.63	2.68	-0 352	-22.902	1.047	0.074	26.16
	4	0.036	-4.00	651	0.003	-0.002	2.40	2.50	0.000	0.000	2.40	2.52	-0 667	-17.951	1.016	0.003	18.38
3	1	0.032	0.00	651	0.003	0.000	2.40	2.50	-0.005	0.000	2 40	2.52	0.000	-0 424	0.974	0.003	0.42
	2	0.034	-2.00	651	0.004	0.000	2.33	2.43	-0.005	0.000	2.33	2.45	0.000	-0.424	0.974	0.004	2.04
	3	0.031	7.00	651	0.011	-0.004	2.37	2.47	-0.001	0.000	2.37	2.49	-0.364	-23.697	1.053	0.012	24.65
	4	0.038	15.00	651	0.022	-0.008	2.41	2.49	-0.001	0.000	2.41	2 50	-0.364	-23.697	1.053	0.023	27.81
4	1	0.035	15.00	651	0.044	-0.014	2.41	2.47	0.000	0.000	2.41	2.48	-0.318	-20.603	1.031	0.045	25.29
	2	0.036	20.00	651	0.078	-0.020	2.56	2.58	0.001	0.000	2.56	2.58	-0.256	-16.758	1.011	0.079	25.87
	3	0.035	3.00	651	0.011	0.006	2.54	2.63	-0.013	0.000	2.54	2.65	0.545	37.807	1.259	0.014	37.91
	4	0.032	13.00	651	0.011	0.002	2.52	2.62	-0.011	0.000	2.52	2.64	0.182	14.925	0.992	0.011	19.70
5	1	0.036	7.00	651	0.011	0.002	2.55	2.64	-0.011	0.000	2.55	2.66	0.182	14.925	0.992	0.011	16.45
	2	0.034	7.00	651	0.022	0.004	2.56	2.64	-0.011	0.000	2.56	2.65	0.182	14.925	0.992	0.022	16.45
	3	0.035	6.00	651	0.025	0.009	2.50	2.58	-0.010	0.000	2.50	2.59	0.360	21.217	1.024	0.026	22.01
	4	0.033	11.00	651	0.026	0.006	2.55	2.63	-0.010	0.000	2.55	2.64	0.231	17.737	1.004	0.026	20.78
6	1	0.032	23.00	651	0.033	0.001	2.66	2.73	-0.006	0.000	2.66	2.74	0.030	2.200	0.973	0.032	23.10
	2	0.034	-18.00	651	0.071	-0.005	2.64	2.67	-0.002	0.000	2.64	2.68	-0.070	-5 882	0.981	0.070	18.91
	3	0.034	-25.00	651	0.014	0.004	2.67	2.76	-0.010	0.000	2.67	2.78	0.286	19.742	1.014	0.014	31.46
	4	0.034	-4.00	651	0.010	0.003	2.68	2.77	-0.010	0.000	2.68	2.79	0.300	20.092	1.017	0.010	20.47
7	1	0.035	0.00	651	0.013	0.001	2.58	2.67	-0.009	0.000	2.58	2.69	0.077	6.382	0.974	0.013	6.38
	2	0.036	-3.00	651	0.021	0.000	2.62	2.70	-0.005	0 000	2.62	2.71	0.000	-0 424	0.974	0.020	3.03
	3	0.037	0.00	651	0.025	-0.003	2.63	2.70	0.000	0.000	2.63	2.71	-0.120	-9.109	0.988	0.025	9.11
	4	0.033	7.00	651	0.076	-0.007	2.72	2.74	-0.001	0.000	2.72	2.74	-0.092	-7.353	0.984	0.075	10.14
8	1	0.036	3.00	651	0.051	-0.001	2.68	2.73	-0.004	0.000	2.68	2.74	-0.020	-2.044	0.976	0.050	3.63
	2	0.037	1.00	651	0.068	0.002	2.59	2.62	-0.006	0.000	2.59	2.63	0.029	2.121	0.973	0.066	2.34
	3	0.034	5.00	651	0.100	0.019	2.73	2.74	-0.011	-0.001	2.73	2.74	0.190	15 461	0.994	0.099	16.23
	4	0.032	8.00	651	0.091	0.020	2.80	2.82	-0.010	-0.001	2.80	2.82	0.220	17 191	1.001	0.091	18.91
9	1	0.037	0.00	651	0.081	0.018	2.80	2.81	-0.010	-0.001	2.80	2.81	0.222	17.317	1.002	0.081	17.32
	2	0.036	1.00	651	0.062	0.016	2.65	2.69	-0.010	-0.001	2.65	2.70	0.258	18.878	1.010	0.063	18.90
	3	0.038	6.00	651	0.059	0.014	2.66	2.70	-0.010	-0.001	2.66	2.71	0 237	18.037	1.005	0.059	18.98
	4	0.035	3.00	651	0.127	0.006	2.70	2.67	-0.007	-0.001	2.70	2.66	0 047	3.710	0 973	0.124	4.77
	37	0.036	0.00	652	0.153	0.017	2.83	2.77	-0.010	-0.001	2.83	2.76	0.111	9.409	0.978	0.150	9.41
	38	0.034	6.00	653	0.167	0.030	2.76	2.69	-0.011	-0.002	2.76	2.68	0.180	14.778	0.992	0.166	15.92
	39	0.036	2.00	654	0.157	0.038	2.86	2.80	-0.010	-0.002	2.86	2.79	0.242	18.245	1.006	0.158	18.35
	40	0.037	2.00	655	0.127	0.034	2.81	2.78	-0.010	-0 001	2.81	2.77	0 268	19.210	1 011	0.128	19.31
	41	0.035	1.00	656	0.106	0.030	2.68	2.68	-0.010	-0.001	2.68	2.68	0.283	19.669	1.014	0.107	19.69
	42	0.033	1.00	657	0.053	0.026	2.65	2.69	-0.010	-0.001	2.65	2.70	0.491	28.761	1.098	0.058	28.78

Avg. Duct Static = 2.65

Yaw Avg. = 2.57	Average Temp.
Std. Dev. = 8.97	652

Pitch Avg = 2.51	Result Angle Avg. = 15.95
Std. Dev. = 15.33	Std. Dev. = 9.21

IP7_037013

12/23/2010

OFA NE ONE THIRD 4-2-03

Traverse Point Velocity	Probes Point Velocity
8.49	19.17
15.79	18.87
19.73	19.16
24.70	18.57
26.03	19.45
26.63	20.02
25.81	18.57
5.53	20.02
5.70	18.87
6.58	19.46
10.32	18.58
14.20	20.57
20.31	19.74
26.66	20.02
9.80	19.73
10.38	18.87
10.57	20.01
14.95	19.45
15.65	19.74
15.93	19.16
17.38	18.87
26.34	19.45
10.72	19.45
9.96	19.45
11.80	19.73
15.07	20.01
16.37	20.29
28.39	19.16
23.48	20.01
27.11	20.29
31.93	19.45
30.11	18.86
28.68	20.28
24.97	20.01
24.29	20.56
36.95	19.73
40.26	20.02
41.31	19.47
39.84	20.04
35.74	20.32
32.63	19.78
22.37	19.21

Traverse	Probes
Avg. Velocity in ft/s	
21.18	19.58

IP7_037015

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		695				
AVERAGE PRESSURE IN. W.C. (Pg)		1.92				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.14	25.14	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	32.04	30.94	
ACTUAL STACK VOLUME (Q acfm) =	123,368	119,116	-3.45
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	47,390	45,756	-3.45
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	47,390	45,756	-3.45
FLOW IN LBS/HR (wet) =	213630	206264	-3.45
FLOW IN LBS/HR (dry) =	213630	206264	-3.45

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.028861
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.09	-2.00	695	0.007	0	2.59	2.68	-0.005	0.000	2.59	2.70	0.000	-0.424	0.974	0.007	2.04
	2	0.083	-9.00	695	0.012	-0.009	2.71	2.8	0.001	0.000	2.71	2.82	-0.750	-14.415	1.002	0.012	16.94
	3	0.079	-9.00	695	0.046	0	2.92	2.98	-0.005	0.000	2.92	2.99	0.000	-0.424	0.974	0.045	9.01
	4	0.09	-4.00	695	0.097	0	2.89	2.89	-0.005	0.000	2.89	2.89	0.000	-0.424	0.974	0.095	4.02
2	1	0.086	3.00	695	0.131	-0.101	3.13	3.1	0.000	0.000	3.13	3.09	-0.771	-18.938	1.021	0.134	19.17
	2	0.088	5.00	695	0.139	-0.085	3.12	3.07	-0.002	0.000	3.12	3.06	-0.612	-25.014	1.065	0.148	25.48
	3	0.086	17.00	695	0.143	-0.039	3.03	2.98	0.001	0.000	3.03	2.97	-0.273	-17.725	1.015	0.145	24.37
	4	0.084	10.00	695	0.03	-0.004	2.7	2.77	0.000	0.000	2.70	2.78	-0.133	-9.903	0.990	0.030	14.04
3	1	0.083	-5.00	695	0.022	-0.009	2.78	2.85	-0.003	0.000	2.78	2.86	-0.409	-26.752	1.083	0.024	27.18
	2	0.082	-7.00	695	0.03	-0.019	2.83	2.9	-0.001	0.000	2.83	2.91	-0.633	-22.367	1.043	0.031	23.38
	3	0.078	-2.00	695	0.052	-0.017	2.85	2.89	0.000	0.000	2.85	2.90	-0.327	-21.186	1.034	0.054	21.28
	4	0.081	-3.00	695	0.08	-0.023	2.58	2.6	0.000	0.000	2.58	2.60	-0.288	-18.630	1.020	0.082	18.86
4	1	0.084	9.00	695	0.117	-0.028	2.45	2.43	0.001	0.000	2.45	2.43	-0.239	-15.777	1.007	0.118	18.11
	2	0.084	8.00	695	0.162	-0.036	2.17	2.1	0.001	0.000	2.17	2.09	-0.222	-14.824	1.004	0.163	16.80
	3	0.084	22.00	695	0.057	0	1.95	1.98	-0.005	0.000	1.95	1.99	0.000	-0.424	0.974	0.056	22.00
	4	0.083	-20.00	695	0.028	-0.001	1.89	1.96	-0.003	0 000	1.89	1.97	-0.036	-3.320	0.977	0.027	20.26
5	1	0.087	-13.00	695	0.027	-0.002	1.56	1.64	-0.002	0.000	1.56	1.65	-0.074	-6.137	0.982	0.027	14.35
	2	0.085	-13.00	695	0.064	-0.007	1.61	1.65	-0.001	0.000	1.61	1.66	-0.109	-8.457	0.987	0.063	15.47
	3	0.084	-12.00	695	0.079	-0.005	1.54	1.57	-0.002	0.000	1.54	1.58	-0.063	-5.377	0.981	0.077	13.13
	4	0.082	-7.00	695	0.096	0.001	1.51	1.51	-0.005	0.000	1.51	1.51	0.010	0.464	0.974	0.093	7.02
6	1	0.082	7.00	695	0.163	-0.007	1.56	1.5	-0.003	0.000	1.56	1.49	-0.043	-3.875	0.978	0.159	8.00
	2	0.082	8.00	695	0.065	-0.006	1.26	1.3	-0.001	0.000	1.26	1.31	-0.092	-7.366	0.984	0.064	10.86
	3	0.088	-25.00	695	0.043	-0.002	1.11	1.17	-0.003	0.000	1.11	1.18	-0.047	-4.145	0.979	0.042	25.32
	4	0.08	-4.00	695	0.039	0	1.53	1.59	-0.005	0.000	1.53	1.60	0.000	-0.424	0.974	0.038	4.02
7	1	0.078	-5.00	695	0.063	0	1.61	1.65	-0.005	0.000	1.61	1.66	0.000	-0.424	0.974	0.061	5.02
	2	0.075	-3.00	695	0.082	-0.002	1.54	1.56	-0.004	0.000	1.54	1.56	-0.024	-2.428	0.976	0.080	3.86
	3	0.083	0.00	695	0.109	0.004	1.51	1.5	-0.007	-0.001	1.51	1.50	0.037	2.767	0.973	0.106	2.77
	4	0.084	-1.00	695	0.16	-0.002	1.35	1.29	-0.004	-0.001	1.35	1.28	-0.013	-1.465	0.975	0.156	1.77
8	1	0.082	6.00	695	0.159	-0.006	1.33	1.27	-0.003	0.000	1.33	1.26	-0.038	-3.476	0.978	0.155	6.93
	2	0.082	2.00	695	0.132	0.001	1.3	1.27	-0.005	-0.001	1.30	1.26	0.008	0.220	0.974	0.129	2.01
	3	0.08	-5.00	695	0.117	0.008	1.33	1.31	-0.008	-0.001	1.33	1.31	0.068	5.613	0.974	0.114	7.51
	4	0.083	0.00	695	0.131	0.012	1.23	1.2	-0.009	-0.001	1.23	1.19	0.092	7.696	0.975	0.128	7.70
9	1	0.081	-1.00	695	0.126	0.024	1.27	1.24	-0.011	-0.001	1.27	1.23	0.190	15.492	0.994	0.125	15.52
	2	0.086	5.00	695	0.12	0.021	1.26	1.24	-0.011	-0.001	1.26	1.24	0.175	14.459	0.991	0.119	15.28
	3	0.079	-6.00	695	0.095	0.022	1.29	1.3	-0.010	-0.001	1.29	1.30	0.232	17.775	1.004	0.095	18.73
	4	0.083	3.00	695	0.268	0.001	1.63	1.45	-0.005	-0.001	1.63	1.42	0.004	-0.108	0.974	0.261	3.00
	37	0.078	0.00	695	0.248	0.012	1.9	1.75	-0.007	-0.002	1.90	1.72	0.048	3.812	0.973	0.241	3.81
	38	0.078	6.00	695	0.238	0.035	1.64	1.5	-0.010	-0.002	1.64	1.48	0.147	12.386	0.984	0.234	13.74
	39	0.078	2.00	695	0.221	0.044	1.62	1.5	-0.011	-0.002	1.62	1.48	0.199	16.027	0.996	0.220	16.15
	40	0.086	2.00	695	0.231	0.059	1.82	1.69	-0.010	-0.002	1.82	1.67	0.255	18.780	1.009	0.233	18.88
	41	0.078	1.00	695	0.17	0.063	1.72	1.65	-0.010	-0.002	1.72	1.64	0.371	21.430	1.025	0.174	21.45
	42	0.081	1.00	695	0.091	0	1.56	1.56	-0.005	0.000	1.56	1.56	0.000	-0.424	0.974	0.089	1.09

Avg. Duct Static = 1.92

Yaw Avg. = -0.93
Std. Dev. = 8.82

Average Temp. 695

Pitch Avg. = -2.80
Std. Dev. = 12.21

Result Angle Avg. = 13.01
Std. Dev. = 7.85

IP7_037017

IP7_037018

Traverse Point Velocity	Probes Point Velocity
8.88	32.26
11.28	30.98
22.48	30.21
32.97	32.25
37.13	31.52
37.34	31.88
37.31	31.52
17.98	31.16
14.76	30.97
17.45	30.79
23.23	30.03
29.07	30.61
35.10	31.18
41.55	31.20
23.52	31.20
16.71	31.02
16.99	31.77
26.08	31.40
29.20	31.22
32.69	30.85
42.60	30.85
26.77	30.86
19.99	31.97
20.95	30.47
26.58	30.08
30.41	29.50
35.04	31.04
42.55	31.23
42.18	30.86
38.61	30.86
36.06	30.48
38.18	31.05
36.75	30.67
35.84	31.60
31.52	30.29
54.97	31.04
52.78	30.08
50.65	30.09
48.56	30.09
49.20	31.58
41.85	30.08
32.07	30.66

Traverse	Probes
Avg. Velocity in ft/s	
32.04	30.94

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		698				
AVERAGE PRESSURE IN. W.C. (Pg)		1.14				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.08	25.08	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	43.22	44.01	
ACTUAL STACK VOLUME (Q acfm) =	166,393	169,421	1.82
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	63,605	64,762	1.82
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	63,605	64,762	1.82
FLOW IN LBS/HR (wet) =	286726	291941	1.82
FLOW IN LBS/HR (dry) =	286726	291941	1.82

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.028720
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037020

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.174	5.00	698	0.049	0.023	1.08	1.14	-0.009	0.000	1.08	1.15	0.469	26.425	1.070	0.052	26.86
	2	0.174	8.00	698	0.055	0.009	1.13	1.18	-0.011	-0.001	1.13	1.19	0.164	13.646	0.988	0.054	15.78
	3	0.17	5.00	698	0.046	-0.031	1.06	1.13	0.001	0.000	1.06	1.14	-0.674	-17.021	1.012	0.047	17.72
	4	0.171	5.00	698	0.071	-0.053	1.06	1.1	0.001	0.000	1.06	1.11	-0.746	-13.987	1.001	0.071	14.84
2	1	0.171	25.00	698	0.124	-0.059	1.18	1.16	-0.005	-0.001	1.18	1.16	-0.476	-30.100	1.125	0.140	38.36
	2	0.169	0.00	698	0.161	-0.078	1.18	1.12	-0.005	-0.001	1.18	1.11	-0.484	-30.341	1.129	0.182	30.34
	3	0.173	-7.00	698	0.168	-0.027	1.19	1.12	0.000	0.000	1.19	1.11	-0.161	-11.462	0.994	0.167	13.41
	4	0.163	2.00	698	0.064	0.006	0.95	1	-0.009	-0.001	0.95	1.01	0.094	7.887	0.976	0.062	8.13
3	1	0.166	12.00	698	0.032	-0.007	0.94	1.02	0.001	0.000	0.94	1.03	-0.219	-14.633	1.003	0.032	18.84
	2	0.168	5.00	698	0.049	-0.015	1	1.06	0.000	0.000	1.00	1.07	-0.306	-19.813	1.026	0.050	20.41
	3	0.165	1.00	698	0.11	-0.025	1.09	1.09	0.001	0.000	1.09	1.09	-0.227	-15.103	1.005	0.111	15.14
	4	0.168	1.00	698	0.164	-0.033	1.09	1.04	0.001	0.000	1.09	1.03	-0.201	-13.675	1.000	0.164	13.71
4	1	0.161	-3.00	698	0.229	-0.048	1.25	1.12	0.001	0.000	1.25	1.10	-0.210	-14.132	1.001	0.229	14.44
	2	0.161	-10.00	698	0.237	-0.031	1.28	1.15	0.000	0.000	1.28	1.13	-0.131	-9.754	0.989	0.234	13.93
	3	0.16	1.00	698	0.107	-0.009	1.19	1.2	-0.001	0.000	1.19	1.20	-0.084	-6.822	0.983	0.105	6.89
	4	0.165	1.00	698	0.071	-0.011	1.18	1.21	0.000	0.000	1.18	1.22	-0.155	-11.139	0.993	0.070	11.18
5	1	0.172	6.00	698	0.07	-0.013	1.26	1.29	0.001	0.000	1.26	1.30	-0.186	-12.833	0.997	0.070	14.15
	2	0.17	7.00	698	0.161	-0.019	1.28	1.23	0.000	0.000	1.28	1.22	-0.118	-8.988	0.988	0.159	11.37
	3	0.164	2.00	698	0.219	-0.017	1.19	1.07	-0.001	0.000	1.19	1.05	-0.078	-6.382	0.982	0.215	6.69
	4	0.174	-2.00	698	0.243	-0.016	1.46	1.32	-0.002	0.000	1.46	1.30	-0.066	-5.559	0.981	0.238	5.91
6	1	0.173	-12.00	698	0.3	-0.01	1.45	1.26	-0.003	-0.001	1.45	1.23	-0.033	-3.135	0.977	0.293	12.40
	2	0.172	8.00	698	0.181	-0.01	1.2	1.12	-0.002	0.000	1.20	1.11	-0.055	-4.794	0.980	0.177	9.32
	3	0.169	9.00	698	0.141	-0.012	1.13	1.09	-0.001	0.000	1.13	1.08	-0.085	-6.889	0.983	0.139	11.32
	4	0.165	12.00	698	0.168	0	1.19	1.12	-0.005	-0.001	1.19	1.11	0.000	-0.424	0.974	0.164	12.01
7	1	0.162	10.00	698	0.167	-0.002	1.11	1.05	-0.004	-0.001	1.11	1.04	-0.012	-1.422	0.975	0.163	10.10
	2	0.167	13.00	698	0.214	-0.006	1.04	0.93	-0.003	-0.001	1.04	0.91	-0.028	-2.718	0.977	0.209	13.28
	3	0.162	1.00	698	0.251	0.009	1.24	1.09	-0.007	-0.002	1.24	1.06	0.036	2.692	0.973	0.244	2.87
	4	0.159	-3.00	698	0.275	0.017	1.28	1.1	-0.008	-0.002	1.28	1.07	0.062	5.022	0.973	0.268	5.85
8	1	0.161	10.00	698	0.271	-0.015	1.19	1.02	-0.002	-0.001	1.19	0.99	-0.055	-4.802	0.980	0.265	11.08
	2	0.16	11.00	698	0.248	-0.006	1.24	1.09	-0.004	-0.001	1.24	1.06	-0.024	-2.413	0.976	0.242	11.26
	3	0.164	13.00	698	0.276	0.004	1.38	1.21	-0.006	-0.001	1.38	1.18	0.014	0.815	0.973	0.269	13.03
	4	0.155	10.00	698	0.274	0.022	1.46	1.28	-0.009	-0.002	1.46	1.25	0.080	6.685	0.974	0.267	12.01
9	1	0.169	5.00	698	0.279	0.038	1.32	1.14	-0.010	-0.003	1.32	1.11	0.136	11.518	0.982	0.274	12.54
	2	0.157	0.00	698	0.239	0.044	1.34	1.2	-0.011	-0.003	1.34	1.18	0.184	15.077	0.993	0.237	15.08
	3	0.171	12.00	698	0.149	0.046	1.18	1.14	-0.010	-0.002	1.18	1.13	0.309	20.281	1.018	0.152	23.44
	4	0.163	13.00	698	0.395	0.004	1.6	1.31	-0.005	-0.002	1.60	1.26	0.010	0.439	0.974	0.385	13.01
	37	0.171	9.00	698	0.348	0.012	1.36	1.11	-0.007	-0.002	1.36	1.07	0.034	2.570	0.973	0.339	9.36
	38	0.165	12.00	698	0.355	0.041	1.45	1.19	-0.010	-0.003	1.45	1.14	0.115	9.786	0.979	0.347	15.44
	39	0.167	14.00	698	0.35	0.073	1.63	1.38	-0.011	-0.004	1.63	1.34	0.209	16.582	0.999	0.350	21.57
	40	0.162	15.00	698	0.317	0.075	1.65	1.43	-0.010	-0.003	1.65	1.39	0.237	18.006	1.005	0.319	23.27
	41	0.163	14.00	698	0.265	0.092	1.45	1.28	-0.010	-0.003	1.45	1.25	0.347	20.984	1.022	0.271	25.05
	42	0.168	18.00	698	0.07	0.02	1.17	1.21	-0.010	-0.001	1.17	1.22	0.286	19.742	1.014	0.071	26.47

-12.00

Avg. Duct Static = 1.14

Yaw Avg. = 6.14	Average Temp.
Std. Dev. = 7.51	698

Pitch Avg. = -1.67	Result Angle Avg. = 14.95
Std. Dev. = 13.59	Std. Dev. = 7.14

IP7_037021

12/23/2010

OFA NW BOTH DAMPERS OPEN 4-2-03

Traverse Point Velocity	Probes Point Velocity
22.04	45.02
24.21	45.02
22.18	44.50
27.81	44.63
31.61	44.63
39.71	44.37
42.90	44.89
26.70	43.58
18.30	43.98
22.68	44.24
34.64	43.84
42.47	44.24
50.06	43.31
50.73	43.31
34.75	43.17
28.11	43.83
27.65	44.75
42.19	44.49
49.73	43.71
52.40	45.01
57.07	44.88
44.85	44.76
39.41	44.37
42.71	43.84
42.89	43.45
48.04	44.12
53.27	43.44
55.55	43.04
54.58	43.31
52.09	43.18
54.50	43.70
54.54	42.48
55.15	44.37
50.76	42.76
38.56	44.63
65.20	43.57
61.97	44.63
61.32	43.84
59.32	44.09
55.94	43.42
50.88	43.57
25.74	44.23

Traverse	Probes
Avg. Velocity in ft/s	
43.22	44.01

IP7_037023

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		687				
AVERAGE PRESSURE IN. W.C. (Pg)		2.17				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.16	25.16	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	29.06	28.56	
ACTUAL STACK VOLUME (Q acfm) =	111,897	109,943	-1.75
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	43,314	42,558	-1.75
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	43,314	42,558	-1.75
FLOW IN LBS/HR (wet) =	195256	191848	-1.75
FLOW IN LBS/HR (dry) =	195256	191848	-1.75

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029083
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.076	0.00	687	0.004	0	1.89	1.99	-0.005	0.000	1.89	2.01	0.000	-0.424	0.974	0.004	0.42
	2	0.074	-5.00	687	0.007	-0.005	2.03	2.13	0.001	0.000	2.03	2.15	-0.714	-13.225	0.999	0.007	14.12
	3	0.074	5.00	687	0.031	-0.024	2.03	2.1	0.000	0.000	2.03	2.11	-0.774	-19.973	1.027	0.032	20.56
	4	0.071	3.00	687	0.05	-0.034	1.95	2	0.001	0.000	1.95	2.01	-0.680	-16.274	1.009	0.050	16.54
2	1	0.073	0.00	687	0.069	-0.044	1.95	1.98	-0.001	0.000	1.95	1.99	-0.638	-21.803	1.039	0.072	21.80
	2	0.067	0.00	687	0.084	-0.039	2.06	2.08	-0.005	0.000	2.06	2.08	-0.464	-29.693	1.120	0.094	29.69
	3	0.065	-11.00	687	0.081	-0.015	2.11	2.13	0.001	0.000	2.11	2.13	-0.185	-12.805	0.997	0.081	16.82
	4	0.071	0.00	687	0.007	-0.004	1.95	2.05	-0.004	0.000	1.95	2.07	-0.571	-28.682	1.107	0.008	28.68
3	1	0.065	2.00	687	0.017	-0.007	2.06	2.15	-0.003	0.000	2.06	2.17	-0.412	-26.921	1.085	0.018	26.99
	2	0.069	5.00	687	0.024	-0.015	2.06	2.15	-0.001	0.000	2.06	2.17	-0.625	-23.419	1.051	0.025	23.92
	3	0.071	3.00	687	0.056	-0.016	2.05	2.1	0.000	0.000	2.05	2.11	-0.286	-18.519	1.019	0.057	18.75
	4	0.075	2.00	687	0.095	-0.028	2.1	2.11	0.000	0.000	2.10	2.11	-0.295	-19.084	1.022	0.097	19.18
4	1	0.068	0.00	687	0.093	-0.028	2.03	2.04	0.000	0.000	2.03	2.04	-0.301	-19.488	1.024	0.095	19.49
	2	0.068	-15.00	687	0.112	-0.018	2.05	2.04	0.000	0.000	2.05	2.04	-0.161	-11.462	0.994	0.111	18.80
	3	0.071	6.00	687	0.032	-0.006	2.11	2.18	0.001	0.000	2.11	2.19	-0.188	-12 930	0.998	0.032	14.23
	4	0.076	8.00	687	0.027	-0.004	2.05	2.13	0.000	0.000	2.05	2.14	-0.148	-10.756	0.992	0.027	13.38
5	1	0.07	11.00	687	0.035	-0.003	2.14	2.21	-0.001	0.000	2.14	2.22	-0 086	-6.929	0.983	0.034	12.98
	2	0.072	10.00	687	0.072	-0.013	2.14	2.17	0.001	0.000	2.14	2.18	-0.181	-12.553	0.997	0.072	16.00
	3	0.067	10.00	687	0.092	-0.009	2.2	2.22	-0.001	0.000	2.20	2.22	-0.098	-7.725	0.985	0.091	12.61
	4	0.066	0.00	687	0.105	-0.006	2.35	2.35	-0.002	0.000	2.35	2.35	-0.057	-4.933	0.980	0.103	4.93
6	1	0.073	-11.00	687	0.14	-0.006	2.3	2.26	-0.003	0.000	2.30	2.25	-0.043	-3.868	0.978	0.137	11.65
	2	0.072	9.00	687	0.066	-0.001	2.23	2.27	-0.004	0.000	2.23	2.28	-0.015	-1.682	0.976	0.064	9.15
	3	0.068	3.00	687	0.061	-0.006	2.2	2.24	-0.001	0.000	2.20	2.25	-0.098	-7.759	0.985	0.060	8.32
	4	0.071	12.00	687	0.06	0.002	2.14	2.18	-0.007	0.000	2.14	2.19	0.033	2.468	0.973	0.058	12.25
7	1	0.074	14.00	687	0.083	0.001	2.2	2.22	-0.005	0.000	2.20	2.22	0.012	0.604	0.974	0.081	14.01
	2	0.064	15.00	687	0.082	0.002	2.07	2.09	-0.006	0.000	2.07	2.09	0.024	1 678	0.973	0.080	15.09
	3	0.072	9.00	687	0.109	0.003	2.28	2.28	-0.006	-0.001	2.28	2.28	0.028	1.954	0.973	0.106	9.21
	4	0.073	-3.00	687	0.125	0.006	2.35	2.33	-0.007	-0.001	2.35	2.33	0.048	3.778	0.973	0.122	4.82
8	1	0.07	5.00	687	0.141	0	2.35	2.32	-0.005	-0.001	2.35	2 31	0.000	-0.424	0.974	0.137	5.02
	2	0.07	9.00	687	0.115	0.004	2.15	2.14	-0.007	-0.001	2.15	2.14	0 035	2.597	0.973	0.112	9.36
	3	0.07	11.00	687	0.113	0.011	2.26	2.25	-0.009	-0.001	2.26	2.25	0.097	8.205	0.976	0.110	13.69
	4	0.074	10.00	687	0.136	0.016	2.38	2.35	-0.010	-0.001	2.38	2.34	0.118	9.970	0.979	0.133	14.08
9	1	0.074	5.00	687	0.135	0.024	2.28	2.25	-0.011	-0.001	2.28	2.24	0 178	14.651	0.991	0.134	15.46
	2	0.073	5.00	687	0.114	0.024	2.17	2.16	-0.011	-0.001	2.17	2.16	0.211	16.692	0.999	0.114	17.40
	3	0.07	8.00	687	0.061	0.021	2.04	2.08	-0.010	-0.001	2.04	2.09	0.344	20.933	1.022	0.062	22.35
	4	0.071	5.00	687	0.223	0.008	2.31	2.19	-0.007	-0.001	2.31	2.17	0.036	2.694	0.973	0.217	5.68
	37	0.071	10.00	687	0.201	0.018	2.27	2.17	-0.009	-0.002	2.27	2.15	0.090	7 513	0.975	0.196	12.49
	38	0.07	10.00	687	0.187	0.03	2.28	2.2	-0.011	-0.002	2.28	2.19	0.160	13.409	0.987	0.185	16.67
	39	0.077	15.00	687	0.19	0.043	2.37	2.28	-0.010	-0.002	2.37	2.26	0.226	17.522	1.003	0.191	22.91
	40	0.068	8.00	687	0.165	0.048	2.28	2.21	-0.010	-0.002	2.28	2.20	0.291	19.876	1.015	0.168	21.37
	41	0.072	10.00	687	0.13	0.054	2.22	2.19	-0.010	-0.001	2.22	2.18	0.415	22.792	1.035	0.135	24.78
	42	0.073	12.00	687	0.043	0	2.1	2.17	-0.005	0.000	2.10	2.18	0.000	-0.424	0.974	0.042	12.01

Avg. Duct Static = 2.17

	Average Temp.
Yaw Avg. = 4.88 Std. Dev. = 6.87	687

Pitch Avg. = -3.91 Std. Dev. = 14.21	Result Angle Avg. = 15.42 Std. Dev. = 6.68

IP7_037025

IP7_037026

Traverse Point Velocity	Probes Point Velocity
6.70	29.57
8 70	29.18
17.92	29.18
23.10	28.58
26.66	28.99
28 58	27.76
29.18	27.35
8.28	28.58
12.98	27.34
15.57	28.17
24.26	28.58
31.56	29.37
31.21	27.97
33.88	27.97
18.58	28.58
17.08	29.57
19.39	28.37
27.62	28.78
31.50	27.76
34.27	27.55
38.87	28.97
26.86	28.77
26.01	27.96
25.32	28.58
29.58	29.17
29.25	27.14
34.47	28.77
37.26	28.97
39.59	28.37
35.40	28.38
34.60	28.37
37.95	29.17
37.81	29.17
34.54	28.98
24.77	28.38
49.71	28.58
46.36	28.58
44.14	28.38
43.12	29.76
40.88	27.97
35.72	28.78
21.47	28.98

Traverse	Probes
Avg. Velocity in ft/s	
29.06	28.56

IP7_037027

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		695				
AVERAGE PRESSURE IN. W.C. (Pg)		1.75				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.13	25.13	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	39.50	40.10	
ACTUAL STACK VOLUME (Q acfm) =	152,070	154,387	1.52
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	58,385	59,274	1.52
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	58,385	59,274	1.52
FLOW IN LBS/HR (wet) =	263194	267202	1.52
FLOW IN LBS/HR (dry) =	263194	267202	1.52

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.028846
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.132	17.00	695	0.019	0	1.41	1.49	-0.005	0.000	1.41	1.50	0.000	-0.424	0.974	0.019	17.01
	2	0.129	0.00	695	0.025	0.007	1.48	1.55	-0.010	0.000	1.48	1.56	0.280	19.585	1.014	0.025	19.59
	3	0.138	4.00	695	0.043	-0.03	1.53	1.59	0.001	0.000	1.53	1.60	-0.698	-14.387	1.002	0.043	14.92
	4	0.134	5.00	695	0.084	-0.044	1.64	1.66	-0.005	-0.001	1.64	1.66	-0.524	-30.602	1.132	0.095	30.97
2	1	0.137	5.00	695	0.118	-0.059	1.67	1.66	-0.005	-0.001	1.67	1.66	-0.500	-30.619	1.133	0.134	30.99
	2	0.133	0.00	695	0.166	-0.061	1.72	1.65	-0.002	0.000	1.72	1.64	-0.367	-23.961	1.055	0.175	23.96
	3	0.137	-7.00	695	0.154	-0.022	1.65	1.59	0.000	0.000	1.65	1.58	-0.143	-10.454	0.991	0.153	12.56
	4	0.136	7.00	695	0.031	0.013	1.58	1.65	-0.009	0.000	1.58	1.66	0.419	22.968	1.037	0.032	23.96
3	1	0.141	5.00	695	0.029	-0.009	1.59	1.66	0.000	0.000	1.59	1.67	-0.310	-20.088	1.028	0.030	20.68
	2	0.138	7.00	695	0.05	-0.02	1.69	1.74	-0.003	0.000	1.69	1.75	-0.400	-26.164	1.077	0.054	27.02
	3	0.136	2.00	695	0.1	-0.018	1.81	1.81	0.001	0.000	1.81	1.81	-0.180	-12.522	0.997	0.100	12.68
	4	0.145	-1.00	695	0.13	-0.028	1.69	1.66	0.001	0.000	1.69	1.65	-0.215	-14.448	1.003	0.130	14.48
4	1	0.135	4.00	695	0.193	-0.037	1.78	1.68	0.001	0.000	1.78	1.66	-0.192	-13.159	0.998	0.193	13.74
	2	0.14	-7.00	695	0.218	-0.027	1.93	1.81	0.000	0.000	1.93	1.79	-0.124	-9.341	0.988	0.215	11.65
	3	0.144	2.00	695	0.074	-0.009	1.41	1.43	0.000	0.000	1.41	1.43	-0.122	-9.207	0.988	0.073	9.42
	4	0.137	8.00	695	0.056	-0.009	1.42	1.46	0.000	0.000	1.42	1.47	-0.161	-11.462	0.994	0.056	13.95
5	1	0.141	6.00	695	0.066	-0.013	1.3	1.34	0.001	0.000	1.30	1.35	-0.197	-13.445	0.999	0.066	14.70
	2	0.134	-2.00	695	0.126	-0.026	1.45	1.43	0.001	0.000	1.45	1.43	-0.206	-13.955	1.001	0.126	14.09
	3	0.142	2.00	695	0.176	-0.021	1.65	1.57	0.000	0.000	1.65	1.56	-0.119	-9.068	0.988	0.174	9.28
	4	0.139	-1.00	695	0.206	-0.014	1.7	1.6	-0.002	0.000	1.70	1.58	-0.068	-5.709	0.981	0.202	5.80
6	1	0.144	-11.00	695	0.265	-0.013	1.67	1.5	-0.002	-0.001	1.67	1.47	-0.049	-4.336	0.979	0.259	11.81
	2	0.132	7.00	695	0.128	-0.008	2.13	2.11	-0.002	0.000	2.13	2.11	-0.063	-5.320	0.981	0.126	8.78
	3	0.139	6.00	695	0.119	-0.008	1.93	1.92	-0.002	0.000	1.93	1.92	-0.067	-5.657	0.981	0.117	8.24
	4	0.142	9.00	695	0.12	-0.004	1.94	1.92	-0.003	0.000	1.94	1.92	-0.033	-3.135	0.977	0.117	9.53
7	1	0.141	13.00	695	0.153	0.004	1.94	1.89	-0.006	-0.001	1.94	1.88	0.026	1.833	0.973	0.149	13.13
	2	0.137	15.00	695	0.179	0.002	1.95	1.87	-0.005	-0.001	1.95	1.86	0.011	0.529	0.974	0.174	15.01
	3	0.14	19.00	695	0.216	0.009	1.97	1.85	-0.007	-0.001	1.97	1.83	0.042	3.210	0.973	0.210	19.26
	4	0.146	0.00	695	0.257	0.009	1.98	1.82	-0.007	-0.002	1.98	1.79	0.035	2.618	0.973	0.250	2.62
8	1	0.148	8.00	695	0.232	-0.01	1.62	1.5	-0.003	-0.001	1.62	1.48	-0.043	-3.887	0.978	0.227	8.89
	2	0.142	9.00	695	0.219	-0.004	1.6	1.48	-0.004	-0.001	1.60	1.46	-0.018	-1.936	0.976	0.214	9.20
	3	0.138	11.00	695	0.227	0.004	1.63	1.5	-0.006	-0.001	1.63	1.48	0.018	1.087	0.973	0.221	11.05
	4	0.14	8.00	695	0.249	0.016	1.64	1.49	-0.008	-0.002	1.64	1.46	0.064	5.241	0.973	0.242	9.55
9	1	0.135	4.00	695	0.228	0.025	1.71	1.58	-0.010	-0.002	1.71	1.56	0.110	9.282	0.978	0.223	10.10
	2	0.138	6.00	695	0.199	0.037	1.72	1.62	-0.011	-0.002	1.72	1.60	0.186	15.198	0.993	0.198	16.31
	3	0.145	10.00	695	0.114	0.043	1.75	1.74	-0.010	-0.001	1.75	1.74	0.377	21.577	1.026	0.117	23.68
	4	0.139	9.00	695	0.327	0	2.85	2.62	-0.005	-0.002	2.85	2.58	0.000	-0.424	0.974	0.319	9.01
	37	0.131	10.00	695	0.319	0.012	2.7	2.47	-0.007	-0.002	2.70	2.43	0.038	2.849	0.973	0.310	10.39
	38	0.141	12.00	695	0.305	0.034	2.53	2.32	-0.010	-0.003	2.53	2.28	0.111	9.440	0.978	0.298	15.23
	39	0.137	12.00	695	0.281	0.056	2.42	2.24	-0.011	-0.003	2.42	2.21	0.199	16.039	0.996	0.280	19.94
	40	0.138	9.00	695	0.262	0.07	2.33	2.16	-0.010	-0.003	2.33	2.13	0.267	19.193	1.011	0.265	21.13
	41	0.145	13.00	695	0.204	0.083	2.2	2.09	-0.010	-0.002	2.20	2.07	0.407	22.451	1.033	0.211	25.77
	42	0.139	15.00	695	0.057	0	2.06	2.11	-0.005	0.000	2.06	2.12	0.000	-0.424	0.974	0.056	15.01

Avg. Duct Static =	1.75

Yaw Avg. = 5.95	Average Temp.
Std. Dev. = 6.42	695

Pitch Avg. = -2.88	Result Angle Avg. = 15.12
Std. Dev. = 13.89	Std. Dev. = 6.62

IP7_037029

Traverse Point Velocity	Probes Point Velocity
14.02	39.14
16.15	38.69
21.61	40.01
28.48	39.43
33.75	39.87
41.20	39.28
41.08	39.87
17.64	39.72
17.39	40.44
22.26	40.01
33.16	39.71
37.65	41.01
45.93	39.57
48.96	40.29
28.74	40.88
24.66	39.88
26.77	40.46
37.11	39.44
44.33	40.59
48.18	40.16
53.71	40.88
37.68	39.11
36.41	40.14
36.36	40.57
40.46	40.43
43.42	39.85
46.60	40.29
53.79	41.15
50.71	41.45
49.16	40.60
49.70	40.02
52.30	40.31
50.07	39.58
45.96	40.01
33.73	41.01
59.96	40.10
58.95	38.94
56.71	40.41
53.53	39.83
51.68	39.98
44.49	40.99
24.50	40.13

IP7_037031

Traverse	Probes
Avg. Velocity in ft/s	
39.50	40.10

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		685				
AVERAGE PRESSURE IN. W.C. (Pg)		1.37				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.10	25.10	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	35.55	29.04	
ACTUAL STACK VOLUME (Q acfm) =	126,197	103,089	-18.31
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	48,820	39,881	-18.31
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	48,820	39,881	-18.31
FLOW IN LBS/HR (wet) =	220076	179780	-18.31
FLOW IN LBS/HR (dry) =	220076	179780	-18.31

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029065
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.074	-5.00	685	0.062	-0.04	1.36	1.4	0.000	0.000	1.36	1.41	-0.645	-20.815	1.032	0.064	21.38
	2	0.072	-2.00	685	0.061	-0.05	1.44	1.48	0.046	0.002	1.44	1.49	-0 820	-48.745	0.578	0.035	48.78
	3	0.077	-3.00	685	0.069	-0.05	1.74	1.77	0.001	0.000	1.74	1.78	-0.725	-12.948	0.998	0.069	13.28
	4	0.073	4.00	685	0.095	-0.05	1.44	1.44	-0.005	-0.001	1.44	1 44	-0.526	-30.566	1.132	0.108	30.80
2	1	0.077	4.00	685	0.118	-0.091	1.39	1.38	0.000	0.000	1.39	1.38	-0.771	-18.997	1.021	0.121	19.40
	2	0.075	11.00	685	0.134	-0.064	1.45	1.42	-0.005	-0.001	1.45	1.41	-0.478	-30.155	1.126	0.151	31.92
	3	0.074	11.00	685	0.146	-0.025	1.63	1.59	0.000	0.000	1.63	1 58	-0.171	-12.043	0.995	0.145	16.26
	4	0.076	-8.00	685	0.052	-0.036	1.2	1.26	0.001	0.000	1.20	1.27	-0.692	-14.904	1.004	0.052	16.87
3	1	0.076	-4.00	685	0.061	-0.034	1.23	1.27	-0.005	0.000	1.23	1.28	-0.557	-29.528	1.118	0.068	29.77
	2	0.074	-1.00	685	0.067	-0.025	1.39	1.43	-0.002	0.000	1.39	1.44	-0.373	-24.351	1.059	0.071	24.37
	3	0.074	1.00	685	0.097	-0.033	1.42	1.43	-0.001	0.000	1.42	1.43	-0.340	-22.086	1.041	0.101	22.11
	4	0.077	5.00	685	0.123	-0.037	1.33	1.31	0.000	0.000	1.33	1.31	-0.301	-19 471	1.024	0.126	20.08
4	1	0.072	8.00	685	0.155	-0.031	1.49	1.44	0.001	0.000	1.49	1.43	-0.200	-13.609	1.000	0.155	15.75
	2	0.073	20.00	685	0.185	-0.016	1.5	1.42	-0.001	0.000	1.50	1.41	-0.086	-6.981	0.984	0.182	21.14
	3	0.072	12.00	685	0.057	0	1.46	1.51	-0.005	0.000	1.46	1.52	0.000	-0.424	0.974	0.056	12.01
	4	0.071	8.00	685	0.069	0.006	1.54	1.57	-0.009	-0.001	1.54	1.58	0.087	7.282	0.975	0.067	10.80
5	1	0.073	2.00	685	0.059	0.006	1.21	1.26	-0.010	-0.001	1.21	1.27	0.102	8.588	0.977	0.058	8.82
	2	0.072	6.00	685	0.07	-0.001	1.34	1.37	-0.004	0.000	1.34	1.38	-0.014	-1.611	0.975	0.068	6.21
	3	0.07	13.00	685	0.109	-0.002	1.4	1.4	-0.004	0.000	1.40	1.40	-0.018	-1.942	0.976	0.106	13.14
	4	0.072	20.00	685	0.154	0.003	1.47	1.42	-0.006	-0.001	1.47	1 41	0.019	1.249	0.973	0.150	20.04
6	1	0.07	28.00	685	0.199	0.003	1.58	1.49	-0.006	-0.001	1.58	1.47	0 015	0.866	0.973	0.194	28.01
	2	0.074	1.00	685	0.137	0.024	1.32	1.28	-0.011	-0.001	1.32	1.27	0.175	14.472	0.991	0.136	14.51
	3	0.075	3.00	685	0.114	0.025	1.29	1.28	-0.010	-0.001	1.29	1.28	0.219	17.166	1.001	0.114	17.42
	4	0.077	1.00	685	0.08	0.025	1.23	1.26	-0.010	-0.001	1.23	1.27	0.313	20.358	1.018	0.081	20.38
7	1	0.076	6.00	685	0.078	0.021	1.18	1.2	-0.010	-0.001	1.18	1.20	0.269	19.259	1.012	0.079	20.14
	2	0.074	10.00	685	0.112	0.021	1.37	1.36	-0.011	-0.001	1.37	1.36	0.188	15.300	0.994	0.111	18.21
	3	0.071	14.00	685	0.158	0.024	1.45	1.4	-0.011	-0.002	1.45	1.39	0.152	12.762	0.985	0.156	18.86
	4	0.072	15.00	685	0.184	0.017	1.42	1.35	-0.009	-0.002	1.42	1.34	0.092	7.766	0.976	0.180	16.85
8	1	0.071	3.00	685	0.162	0.039	1.21	1.15	-0.010	-0.002	1.21	1.14	0.241	18.189	1.006	0.163	18.43
	2	0.07	5.00	685	0.171	0.04	1.2	1.14	-0.010	-0.002	1.20	1.13	0.234	17.884	1.005	0.172	18.55
	3	0.073	5.00	685	0.143	0.044	1.25	1.21	-0.010	-0.001	1.25	1.20	0.308	20.259	1.018	0.146	20.84
	4	0.07	7.00	685	0.145	0.047	1.26	1.22	-0.010	-0.001	1.26	1.21	0.324	20.579	1.020	0.148	21.69
9	1	0.07	12.00	685	0.158	0.046	1.39	1.34	-0.010	-0.002	1.39	1.33	0.291	19.882	1.015	0.160	23.10
	2	0.07	10.00	685	0.172	0.04	1.41	1.34	-0.010	-0.002	1.41	1.33	0 233	17 821	1.004	0.173	20.36
	3	0.072	9.00	685	0.186	0.018	1.46	1.38	-0.009	-0.002	1.46	1.37	0.097	8.154	0.976	0.182	12.12
	4	0.076	2.00	685	0.2	0.028	1.63	1.54	-0.010	-0.002	1.63	1.52	0.140	11.825	0.983	0.197	11.99
	37	0.078	2.00	685	0.21	0.047	1.5	1.39	-0.010	-0.002	1.50	1.37	0.224	17.397	1.002	0.210	17.51
	38	0.076	2.00	685	0.203	0.063	1.4	1.3	-0.010	-0.002	1.40	1 28	0.310	20.314	1.018	0.207	20.41
	39	0.072	3.00	685	0.199	0.071	1.41	1.31	-0.010	-0.002	1.41	1.29	0.357	21.157	1.023	0.204	21.36
	40	0.071	7.00	685	0.176	0.061	1.49	1.41	-0.010	-0.002	1.49	1.40	0.347	20.974	1.022	0.180	22.06
	41	0.072	9.00	685	0.151	0.036	1.47	1.42	-0.010	-0.002	1.47	1.41	0.238	18.087	1.006	0.152	20.14
	42	0.074	9.00	685	0.174	0.006	1.41	1.34	-0.007	-0.001	1.41	1.33	0 034	2.570	0.973	0.169	9.36

-12.00

Avg. Duct Static = 1.37

Yaw Avg. = 6.31 Std. Dev. = 7.06	Average Temp. 685

Pitch Avg. = 1.21 Std. Dev = 18.66	Result Angle Avg. = 19.41 Std. Dev. = 7.29

IP7_037033

IP7_037034

Traverse Point Velocity	Probes Point Velocity
25.27	29.18
13.27	28.78
27.38	29.75
30.21	28.98
35.13	29.77
35.37	29.38
39.25	29.17
23.46	29.58
24.32	29.58
26.03	29.18
31.57	29.18
35.76	29.77
40.64	28.78
42.68	28 98
24.72	28.78
27.33	28.58
25.45	28.99
27.87	28.79
34.07	28.38
39.02	28.79
41.68	28.38
38.27	29.19
34.59	29.38
28.71	29.77
28.30	29.58
34.00	29.18
40.06	28.59
43.50	28.79
41.10	28.60
42.17	28.39
38.26	28.99
38.34	28.39
39.53	28.39
41.81	28.39
44.69	28.79
46.52	29.57
46.94	29.96
45.71	29.58
45.09	28.79
42.17	28.59
39.25	28.79
43.56	29.19

Traverse	Probes
Avg. Velocity in ft/s	
35.55	29.04

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		685				
AVERAGE PRESSURE IN. W.C. (Pg)		1.37				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.10	25.10	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	35.52	29.04	
ACTUAL STACK VOLUME (Q acfm) =	126,083	103,089	-18.24
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	48,776	39,881	-18.24
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	48,776	39,881	-18.24
FLOW IN LBS/HR (wet) =	219878	179780	-18.24
FLOW IN LBS/HR (dry) =	219878	179780	-18.24

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029065
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037036

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.074	-5.00	685	0.062	-0.03	1.36	1.4	-0.005	0.000	1.36	1.41	-0.484	-30.326	1.128	0.070	30.70
	2	0.072	-2.00	685	0.061	-0.05	1.44	1.48	0.046	0.002	1.44	1.49	-0.820	-48.745	0.578	0.035	48.78
	3	0.077	-3.00	685	0.069	-0.02	1.74	1.77	0.000	0.000	1.74	1.78	-0.290	-18.777	1.020	0.070	19.01
	4	0.073	4.00	685	0.095	-0.05	1.44	1.44	-0.005	-0.001	1.44	1.44	-0.526	-30 566	1.132	0.108	30.80
2	1	0.077	4.00	685	0.118	-0.091	1.39	1.38	0.000	0.000	1.39	1.38	-0.771	-18.997	1.021	0.121	19.40
	2	0.075	11.00	685	0.134	-0.064	1.45	1.42	-0.005	-0.001	1.45	1.41	-0.478	-30.155	1.126	0.151	31.92
	3	0.074	11.00	685	0.146	-0.025	1.63	1.59	0.000	0.000	1.63	1.58	-0.171	-12.043	0.995	0.145	16.26
	4	0.076	-8.00	685	0.052	-0.036	1.2	1.26	0.001	0.000	1.20	1.27	-0.692	-14.904	1.004	0.052	16.87
3	1	0.076	-4.00	685	0.061	-0.034	1.23	1.27	-0.005	0.000	1.23	1.28	-0 557	-29.528	1.118	0.068	29.77
	2	0.074	-1.00	685	0.067	-0.025	1.39	1.43	-0.002	0.000	1.39	1.44	-0.373	-24.351	1.059	0.071	24.37
	3	0.074	1.00	685	0.097	-0.033	1.42	1.43	-0.001	0.000	1.42	1.43	-0.340	-22.086	1.041	0.101	22.11
	4	0.077	5.00	685	0.123	-0.037	1.33	1.31	0.000	0.000	1.33	1.31	-0.301	-19.471	1.024	0.126	20.08
4	1	0.072	8.00	685	0.155	-0.031	1.49	1.44	0.001	0.000	1.49	1 43	-0.200	-13.609	1.000	0.155	15.75
	2	0.073	20.00	685	0.185	-0.016	1.5	1.42	-0.001	0.000	1.50	1.41	-0.086	-6.981	0.984	0.182	21.14
	3	0.072	12.00	685	0.057	0	1.46	1.51	-0.005	0.000	1.46	1.52	0.000	-0.424	0.974	0.056	12.01
	4	0.071	8.00	685	0.069	0.006	1.54	1.57	-0.009	-0.001	1.54	1.58	0.087	7.282	0.975	0.067	10.80
5	1	0.073	2.00	685	0.059	0.006	1.21	1.26	-0.010	-0.001	1.21	1.27	0.102	8.588	0.977	0.058	8.82
	2	0.072	6.00	685	0.07	-0.001	1.34	1.37	-0.004	0.000	1.34	1.38	-0.014	-1.611	0.975	0.068	6.21
	3	0.07	13.00	685	0.109	-0.002	1.4	1.4	-0.004	0.000	1.40	1.40	-0.018	-1.942	0.976	0.106	13.14
	4	0.072	20.00	685	0.154	0.003	1.47	1.42	-0.006	-0.001	1.47	1.41	0.019	1.249	0.973	0.150	20.04
6	1	0.07	28.00	685	0.199	0.003	1.58	1.49	-0.006	-0.001	1.58	1.47	0.015	0.866	0.973	0.194	28.01
	2	0.074	1.00	685	0.137	0.024	1.32	1.28	-0.011	-0.001	1.32	1.27	0.175	14.472	0.991	0.136	14.51
	3	0.075	3.00	685	0.114	0.025	1.29	1.28	-0.010	-0.001	1.29	1.28	0.219	17.166	1.001	0.114	17.42
	4	0.077	1.00	685	0.08	0.025	1.23	1.26	-0.010	-0.001	1.23	1.27	0.313	20.358	1.018	0.081	20.38
7	1	0.076	6.00	685	0.078	0.021	1.18	1.2	-0.010	-0.001	1.18	1.20	0.269	19.259	1.012	0.079	20.14
	2	0.074	10.00	685	0.112	0.021	1.37	1.36	-0.011	-0.001	1.37	1.36	0.188	15.300	0.994	0.111	18.21
	3	0.071	14.00	685	0.158	0.024	1.45	1.4	-0.011	-0.002	1.45	1.39	0.152	12.762	0.985	0.156	18.86
	4	0.072	15.00	685	0.184	0.017	1.42	1.35	-0.009	-0.002	1.42	1.34	0.092	7.766	0.976	0.180	16.85
8	1	0.071	3.00	685	0.162	0.039	1.21	1.15	-0.010	-0.002	1.21	1.14	0.241	18.189	1.006	0.163	18.43
	2	0.07	5.00	685	0.171	0.04	1.2	1.14	-0.010	-0.002	1.20	1.13	0.234	17.884	1.005	0.172	18.55
	3	0.073	5.00	685	0.143	0.044	1.25	1.21	-0.010	-0.001	1.25	1.20	0.308	20.259	1.018	0.146	20.84
	4	0.07	7.00	685	0.145	0.047	1.26	1.22	-0.010	-0.001	1.26	1.21	0.324	20.579	1.020	0.148	21.69
9	1	0.07	12.00	685	0.158	0.046	1.39	1.34	-0.010	-0.002	1.39	1.33	0.291	19.882	1.015	0.160	23.10
	2	0.07	10.00	685	0.172	0.04	1.41	1.34	-0.010	-0.002	1.41	1.33	0.233	17.821	1.004	0.173	20.36
	3	0.072	9.00	685	0.186	0.018	1.46	1.38	-0 009	-0.002	1.46	1.37	0.097	8.154	0.976	0.182	12.12
	4	0.076	2.00	685	0.2	0.028	1.63	1.54	-0.010	-0.002	1.63	1.52	0.140	11.825	0.983	0.197	11.99
	37	0.078	2.00	685	0.21	0.047	1.5	1.39	-0.010	-0.002	1.50	1.37	0.224	17.397	1.002	0.210	17.51
	38	0.076	2.00	685	0.203	0.063	1.4	1.3	-0.010	-0.002	1.40	1.28	0.310	20.314	1.018	0.207	20.41
	39	0.072	3.00	685	0.199	0.071	1.41	1.31	-0.010	-0.002	1.41	1.29	0.357	21.157	1.023	0.204	21.36
	40	0.071	7.00	685	0.176	0.061	1.49	1.41	-0.010	-0.002	1.49	1.40	0.347	20.974	1.022	0.180	22.06
	41	0.072	9.00	685	0.151	0.036	1.47	1.42	-0.010	-0.002	1.47	1.41	0.238	18.087	1.006	0.152	20.14
	42	0.074	9.00	685	0.174	0.006	1.41	1.34	-0.007	-0.001	1.41	1.33	0.034	2.570	0.973	0.169	9.36

-12.00

Avg. Duct Static = 1.37

Yaw Avg. = 6.31
Std. Dev. = 7.06

Average Temp. 685

Pitch Avg. = 0.85
Std. Dev. = 19.11

Result Angle Avg. = 19.77
Std. Dev. = 7.42

IP7_037037

OFA SE ONE THIRD OPEN 4-2-03

IP7_037038

Traverse Point Velocity	Probes Point Velocity
24.40	29.18
13.27	28.78
26.90	29.75
30.21	28.98
35.13	29.77
35.37	29.38
39.25	29.17
23.46	29.58
24.32	29.58
26.03	29.18
31.57	29.18
35.76	29.77
40.64	28.78
42.68	28.98
24.72	28.78
27.33	28.58
25.45	28.99
27.87	28.79
34.07	28.38
39.02	28.79
41.68	28.38
38.27	29.19
34.59	29.38
28.71	29.77
28.30	29.58
34.00	29.18
40.06	28.59
43.50	28.79
41.10	28.60
42.17	28.39
38.26	28.99
38.34	28.39
39.53	28.39
41.81	28.39
44.69	28.79
46.52	29.57
46.94	29.96
45.71	29.58
45.09	28.79
42.17	28.59
39.25	28.79
43.56	29.19

Traverse	Probes
Avg. Velocity in ft/s	
35.52	29.04

IP7_037039

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		685				
AVERAGE PRESSURE IN. W.C. (Pg)		1.98				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.15	25.15	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	23.08	18.80	
ACTUAL STACK VOLUME (Q acfm) =	81,938	66,724	-18.57
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	31,755	25,859	-18.57
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	31,755	25,859	-18.57
FLOW IN LBS/HR (wet) =	143149	116570	-18.57
FLOW IN LBS/HR (dry) =	143149	116570	-18.57

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029117
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.031	1.00	685	0.018	0	1.9	1.98	-0.005	0.000	1.90	1.99	0.000	-0.424	0.974	0.018	1.09
	2	0.031	5.00	685	0.025	0	2	2.08	-0.005	0.000	2.00	2.09	0.000	-0.424	0.974	0.024	5.02
	3	0.031	7.00	685	0.032	-0.02	2.1	2.17	-0.001	0.000	2.10	2.18	-0.625	-23.419	1.051	0.034	24.39
	4	0.033	3.00	685	0.047	0	1.87	1.93	-0.005	0.000	1.87	1.94	0.000	-0.424	0.974	0.046	3.03
2	1	0.032	5.00	685	0.053	0	1.94	1.99	-0.005	0.000	1.94	2.00	0.000	-0.424	0.974	0.052	5.02
	2	0.03	8.00	685	0.065	-0.041	1.91	1.95	-0.001	0.000	1.91	1.96	-0.631	-22.695	1.045	0.068	23.99
	3	0.031	12.00	685	0.074	-0.018	2.06	2.09	0.001	0.000	2.06	2.10	-0.243	-16.000	1.008	0.075	19.91
	4	0.031	-5.00	685	0.021	-0.01	1.86	1.94	-0.005	0.000	1.86	1.95	-0.476	-30.112	1.126	0.024	30.49
3	1	0.032	6.00	685	0.026	-0.015	1.74	1.82	-0.004	0.000	1.74	1.83	-0.577	-28.287	1.102	0.029	28.86
	2	0.031	5.00	685	0.026	-0.014	1.97	2.04	-0.005	0.000	1.97	2.05	-0.538	-30.293	1.128	0.029	30.66
	3	0.031	0.00	685	0.041	-0.015	2.05	2.12	-0.002	0.000	2.05	2.13	-0.366	-23.850	1.055	0.043	23.85
	4	0.031	5.00	685	0.05	-0.018	1.94	1.99	-0.001	0.000	1.94	2.00	-0.360	-23.446	1.051	0.053	23.94
4	1	0.032	12.00	685	0.07	-0.019	1.92	1.95	0.001	0.000	1.92	1.96	-0.271	-17.646	1.015	0.071	21.23
	2	0.031	30.00	685	0.086	-0.011	1.83	1.84	0.000	0.000	1.83	1.84	-0.128	-9.583	0.989	0.085	31.36
	3	0.03	8.00	685	0.02	-0.001	1.76	1.84	-0.002	0.000	1.76	1.85	-0.050	-4.406	0.979	0.020	9.13
	4	0.028	3.00	685	0.019	0	1.82	1.91	-0.005	0.000	1.82	1.93	0.000	-0.424	0.974	0.019	3.03
5	1	0.032	4.00	685	0.013	0.001	1.82	1.9	-0.009	0.000	1.82	1.91	0.077	6.382	0.974	0.013	7.53
	2	0.031	6.00	685	0.032	0	1.89	1.96	-0.005	0.000	1.89	1.97	0.000	-0.424	0.974	0.031	6.01
	3	0.03	10.00	685	0.04	0	1.94	2	-0.005	0.000	1.94	2.01	0.000	-0.424	0.974	0.039	10.01
	4	0.029	13.00	685	0.064	0.001	1.98	2.02	-0.006	0.000	1.98	2.03	0.016	0.913	0.973	0.062	13.03
6	1	0.029	37.00	685	0.082	0.001	2.03	2.05	-0.005	0.000	2.03	2.05	0.012	0.617	0.974	0.080	37.00
	2	0.031	0.00	685	0.036	0.006	1.84	1.9	-0.011	0.000	1.84	1.91	0.167	13.867	0.989	0.036	13.87
	3	0.033	7.00	685	0.036	0.006	1.78	1.85	-0.011	0.000	1.78	1.86	0.167	13.867	0.989	0.036	15.50
	4	0.029	4.00	685	0.034	0.012	1.98	2.05	-0.010	0.000	1.98	2.06	0.353	21.087	1.023	0.035	21.45
7	1	0.033	5.00	685	0.037	0.01	1.78	1.85	-0.010	0.000	1.78	1.86	0.270	19.293	1.012	0.037	19.91
	2	0.029	12.00	685	0.042	0.009	1.75	1.81	-0.010	0.000	1.75	1.82	0.214	16.899	1.000	0.042	20.62
	3	0.029	12.00	685	0.05	0.007	1.75	1.8	-0.010	-0.001	1.75	1.81	0.140	11.825	0.983	0.049	16.79
	4	0.029	25.00	685	0.073	0.006	1.88	1.91	-0.009	-0.001	1.88	1.92	0.082	6.855	0.975	0.071	25.86
8	1	0.03	1.00	685	0.071	0.025	1.81	1.84	-0.010	-0.001	1.81	1.85	0.352	21.072	1.023	0.073	21.09
	2	0.029	7.00	685	0.065	0.021	1.85	1.89	-0.010	-0.001	1.85	1.90	0.323	20.559	1.019	0.066	21.67
	3	0.032	7.00	685	0.068	0.03	1.97	2	-0.009	-0.001	1.97	2.01	0.441	24.167	1.047	0.071	25.10
	4	0.032	11.00	685	0.068	0.028	1.97	2.01	-0.010	-0.001	1.97	2.02	0.412	22.641	1.034	0.070	25.04
9	1	0.033	10.00	685	0.076	0.026	2.07	2.1	-0.010	-0.001	2.07	2.11	0.342	20.896	1.022	0.078	23.07
	2	0.03	15.00	685	0.066	0.02	1.91	1.95	-0.010	-0.001	1.91	1.96	0.303	20.160	1.017	0.067	24.94
	3	0.03	22.00	685	0.083	0.013	1.9	1.93	-0.011	-0.001	1.90	1.94	0.157	13.123	0.986	0.082	25.45
	4	0.03	-2.00	685	0.091	0.023	2.04	2.06	-0.010	-0.001	2.04	2.06	0.253	18.679	1.009	0.092	18.78
	37	0.031	5.00	685	0.114	0.036	1.96	1.95	-0.010	-0.001	1.96	1.95	0.316	20.422	1.019	0.116	21.00
	38	0.031	1.00	685	0.105	0.047	1.87	1.87	-0.009	-0.001	1.87	1.87	0.448	24.606	1.051	0.110	24.62
	39	0.029	6.00	685	0.1	0.048	1.98	1.98	-0.009	-0.001	1.98	1.98	0.480	27.521	1.082	0.108	28.12
	40	0.032	6.00	685	0.089	0.042	2.08	2.1	-0.009	-0.001	2.08	2.10	0.472	26.672	1.072	0.095	27.29
	41	0.032	8.00	685	0.079	0.03	2.11	2.13	-0.010	-0.001	2.11	2.13	0.380	21.637	1.027	0.081	23.00
	42	0.031	7.00	685	0.085	0.006	2.09	2.1	-0.008	-0.001	2.09	2.10	0.071	5.812	0.974	0.083	9.09

-12.00

Avg. Duct Static = 1.98

Yaw Avg. = 8.19 Std. Dev. = 8.06	Average Temp. 685

Pitch Avg. = 3.97 Std. Dev. = 17.71	Result Angle Avg. = 19.31 Std. Dev. = 8.92

IP7_037041

Traverse Point Velocity	Probes Point Velocity
14.19	18.87
16.66	18.87
17.90	18.87
22.91	19.47
24.26	19.17
25.52	18.57
27.52	18.87
14.20	18.87
15.89	19.18
15.79	18.87
20.38	18.87
22.46	18.87
26.63	19.17
26.70	18.88
14.81	18.57
14.56	17.94
11.96	19.18
18.82	18.87
20.84	18.56
26.06	18.25
24.18	18.25
19.63	18.87
19.49	19.47
18.60	18.25
19.50	19.47
20.56	18.26
22.76	18.26
25.73	18.25
26.95	18.57
25.65	18.26
25.90	19.17
25.75	19.17
27.47	19.47
25.18	18.57
27.70	18.57
30.74	18.56
34.10	18.87
32.37	18.88
31.10	18.25
29.42	19.17
28.09	19.17
30.44	18.87

Traverse	Probes
Avg. Velocity in ft/s	
23.08	18.80

IP7_037043

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		685				
AVERAGE PRESSURE IN. W.C. (Pg)		1.68				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (*0.0*)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.12	25.12	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	52.71	47.30	
ACTUAL STACK VOLUME (Q acfm) =	187,118	167,904	-10.27
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	72,470	65,028	-10.27
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	72,470	65,028	-10.27
FLOW IN LBS/HR (wet) =	326688	293141	-10.27
FLOW IN LBS/HR (dry) =	326688	293141	-10.27

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029098
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.198	10.00	675	0.101	-0.05	1.56	1.56	-0 005	-0.001	1.56	1.56	-0.495	-30.553	1.132	0.114	32.00
	2	0.193	10.00	685	0.137	-0.096	1.7	1.66	0.001	0.000	1.70	1.65	-0.701	-14.119	1.001	0.137	17.24
	3	0.192	15.00	685	0.168	-0.105	1.83	1.76	-0.001	0.000	1.83	1.75	-0.625	-23.419	1.051	0.177	27.58
	4	0.192	3.00	685	0.176	-0.1	1.87	1.79	-0.004	-0.001	1.87	1.78	-0.568	-28.899	1.109	0.195	29.04
2	1	0.193	0.00	685	0.208	-0.105	1.87	1.76	-0.005	-0.001	1.87	1 74	-0.505	-30.661	1.133	0.236	30.66
	2	0.193	4.00	685	0.255	-0.075	1.92	1.76	0.000	0.000	1.92	1.73	-0.294	-19.045	1.022	0.261	19.45
	3	0.201	-5.00	685	0.309	-0.035	1.98	1.77	0.000	0.000	1.98	1.73	-0.113	-8.698	0.987	0.305	10.02
	4	0.198	-4.00	685	0.098	-0.052	1.6	1.6	-0.005	-0.001	1.60	1.60	-0.531	-30.489	1.131	0.111	30.72
3	1	0.202	14.00	685	0.111	-0.042	1.62	1.61	-0.002	0.000	1.62	1 61	-0.378	-24.711	1.062	0.118	28.18
	2	0.191	13.00	685	0.127	-0.034	1.62	1.59	0.001	0.000	1.62	1.58	-0.268	-17.424	1.014	0.129	21.62
	3	0.194	9.00	685	0.174	-0.037	1.7	1.63	0.001	0.000	1.70	1.62	-0.213	-14.298	1.002	0.174	16.84
	4	0.192	-3.00	685	0.231	-0.038	1.79	1.66	0.000	0.000	1.79	1.64	-0.165	-11.672	0.994	0.230	12.05
4	1	0.192	-4.00	685	0.295	-0.024	1.86	1.67	-0.001	0.000	1.86	1.64	-0.081	-6.636	0.983	0.290	7.74
	2	0.194	-3.00	685	0.377	-0.009	2.08	1.8	-0.004	-0.001	2.08	1.75	-0.024	-2.387	0.976	0.368	3.83
	3	0.199	-2.00	685	0.147	0.009	1.87	1.82	-0.008	-0.001	1.87	1.81	0 061	4.968	0.973	0.143	5.35
	4	0.195	1.00	685	0.156	0.013	1.85	1.79	-0.009	-0.001	1.85	1.78	0.083	6.958	0.975	0.152	7.03
5	1	0.194	4.00	685	0.143	0.011	1.84	1.8	-0.009	-0.001	1.84	1.79	0.077	6.382	0.974	0.139	7.53
	2	0.195	5.00	685	0.143	0.015	1.82	1.78	-0.010	-0.001	1.82	1.77	0.105	8 868	0.977	0.140	10.17
	3	0.198	0.00	685	0.214	0.013	1.91	1.79	-0.008	-0.002	1.91	1.77	0.061	4.925	0.973	0.208	4.93
	4	0.192	-7.00	685	0.304	0.009	1.95	1.74	-0.006	-0.002	1.95	1.70	0.030	2.138	0.973	0.296	7.32
6	1	0.195	-12.00	685	0.373	0.013	2.04	1.76	-0.007	-0.002	2.04	1.71	0.035	2.603	0.973	0.363	12.27
	2	0.192	-1.00	685	0.278	0.052	1.84	1.66	-0.011	-0.003	1.84	1.63	0.187	15.271	0.993	0.276	15.30
	3	0.196	1.00	685	0.227	0.061	1.84	1.72	-0.010	-0.002	1.84	1.70	0.269	19.243	1.012	0.230	19.27
	4	0.196	4.00	685	0.226	0.061	1.88	1.75	-0.010	-0.002	1.88	1.73	0.270	19.281	1.012	0.229	19.68
7	1	0.199	-1.00	685	0.237	0.064	1.9	1.76	-0.010	-0.002	1.90	1.74	0 270	19.285	1.012	0.240	19.31
	2	0.198	-3.00	685	0.259	0.06	1.99	1.84	-0.010	-0.003	1.99	1.81	0.232	17.779	1.004	0.260	18.02
	3	0.197	-20.00	685	0.307	0.057	1.74	1.53	-0.011	-0.003	1.74	1.49	0.186	15.180	0.993	0.305	24.92
	4	0.198	-20.00	685	0.357	0.039	2.05	1.79	-0.010	-0.003	2.05	1.74	0.109	9.247	0.978	0.349	21.95
8	1	0.186	6.00	685	0.417	0.1	2.02	1.69	-0.010	-0.004	2.02	1.63	0.240	18.148	1.006	0.419	19.08
	2	0.191	0.00	685	0.395	0.101	2	1.69	-0.010	-0.004	2.00	1.64	0.256	18.790	1.009	0.399	18.79
	3	0.193	3.00	685	0.354	0.113	2.05	1.8	-0.010	-0.004	2.05	1.76	0.319	20.487	1.019	0.361	20.70
	4	0.191	-3.00	685	0.382	0.123	2.1	1.81	-0.010	-0.004	2.10	1.76	0.322	20.539	1.019	0.389	20.75
9	1	0.193	2.00	685	0.392	0.124	1.97	1.66	-0.010	-0.004	1.97	1.61	0.316	20.433	1.019	0.399	20.53
	2	0.197	-3.00	685	0.4	0.114	1.96	1.66	-0.010	-0.004	1.96	1.61	0.285	19.723	1.014	0.406	19.94
	3	0.197	0.00	685	0.385	0.071	1.99	1.7	-0.011	-0.004	1.99	1.65	0.184	15.098	0.993	0.382	15.10
	4	0.198	4.00	685	0.459	0.084	1.97	1.6	-0.011	-0.005	1.97	1.54	0.183	15.004	0.992	0.456	15.52
	37	0.192	4.00	685	0.45	0.101	2.04	1.68	-0.010	-0.005	2.04	1.62	0.224	17.429	1.002	0.451	17.87
	38	0.193	8.00	685	0.445	0.128	2.01	1.66	-0.010	-0.005	2.01	1.60	0.288	19.793	1.015	0.452	21.29
	39	0.198	4.00	685	0.439	0.132	2.15	1.8	-0.010	-0.004	2.15	1.74	0.301	20.108	1.017	0.446	20.49
	40	0.198	2.00	685	0.415	0.113	2.08	1.75	-0.010	-0.004	2.08	1.69	0.272	19.356	1.012	0.420	19.46
	41	0.189	0.00	685	0.35	0.078	1.94	1.68	-0.010	-0.004	1.94	1.63	0.223	17.349	1.002	0.351	17.35
	42	0.188	2.00	685	0.284	0.014	1.83	1.65	-0.007	-0.002	1.83	1.62	0.049	3.894	0.973	0.276	4.38

-12.00

Avg. Duct Static = 1 68

Yaw Avg. = 0.88 Std. Dev. = 7.31	Average Temp. 685

Pitch Avg. = 3.22 Std. Dev. = 17.44	Result Angle Avg. = 17.41 Std. Dev. = 7.55

IP7_037045

12/23/2010

OFA SW BOTH DAMPERS OPEN 4-2-03

Traverse Point Velocity	Probes Point Velocity
30.62	47.52
37.94	47.11
39.93	46.98
41.42	46.98
44.78	47.11
51.61	47.11
58.31	48.07
30.69	47.72
32.46	48.20
35.78	46.87
42.86	47.24
50.26	46.99
57.22	46.99
64.90	47.23
40.38	47.83
41.49	47.35
39.67	47.22
39.45	47.35
48.75	47.71
57.84	46.99
63.12	47.35
54.36	46.99
48.51	47.47
48.28	47.47
49.55	47.83
51.99	47.71
53.71	47.61
58.75	47.71
65.64	46.25
64.10	46.87
60.24	47.10
62.57	46.86
63.47	47.11
64.22	47.60
64.01	47.60
69.75	47.73
68.55	46.99
67.15	47.12
67.10	47.71
65.53	47.72
60.62	46.62
56.21	46.50

Traverse	Probes
Avg. Velocity in ft/s	
52.71	47.30

IP7_037047

3D PROBE WORK SHEET

PROJECT:--- *Inter-Mountain*
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		659				
AVERAGE PRESSURE IN. W.C. (Pg)		1.89				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.14	25.14	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	30.10	25.45	
ACTUAL STACK VOLUME (Q acfm) =	106,839	90,335	-15.45
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	42,356	35,813	-15.45
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	42,356	35,813	-15.45
FLOW IN LBS/HR (wet) =	190937	161442	-15.45
FLOW IN LBS/HR (dry) =	190937	161442	-15.45

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029786
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	*0.075132*

IP7_037048

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.056	5.00	659	0.046	-0.02	2.01	2.07	-0.004	0.000	2.01	2.08	-0.435	-28.285	1.102	0.051	28.69
	2	0.054	3.00	659	0.051	-0.02	1.95	2.01	-0.002	0.000	1.95	2.02	-0.392	-25.644	1.071	0.055	25.81
	3	0.053	-12.00	659	0.057	-0.038	1.5	1.57	0.000	0.000	1.50	1.58	-0.667	-17.951	1.016	0.058	21.48
	4	0.058	-3.00	659	0.068	-0.04	1.34	1.36	-0.003	0.000	1.34	1.36	-0.588	-27.362	1.090	0.074	27.51
2	1	0.055	3.00	659	0.075	-0.038	1.43	1.37	-0.005	0.000	1.43	1.36	-0.507	-30.671	1.133	0.085	30.80
	2	0.055	7.00	659	0.085	-0.028	1.44	1.36	0.000	0.000	1.44	1.35	-0.329	-21.353	1.035	0.088	22.42
	3	0.058	1.00	659	0.104	-0.012	1.97	1.97	0.000	0.000	1.97	1.97	-0.115	-8.828	0.987	0.103	8.88
	4	0.059	13.00	659	0.027	-0.017	1.77	1.85	-0.001	0.000	1.77	1.86	-0.630	-22.840	1.046	0.028	26.11
3	1	0.06	2.00	659	0.036	-0.023	1.82	1.89	-0.001	0.000	1.82	1.90	-0.639	-21.645	1.037	0.037	21.73
	2	0.06	6.00	659	0.06	-0.022	1.88	1.93	-0.002	0.000	1.88	1.94	-0.367	-23.906	1.055	0.063	24.60
	3	0.06	11.00	659	0.073	-0.02	1.87	1.9	0.001	0.000	1.87	1.91	-0.274	-17.800	1.016	0.074	20.83
	4	0.06	10.00	659	0.094	-0.02	1.92	1.93	0.001	0.000	1.92	1.93	-0.213	-14.305	1.002	0.094	17.39
4	1	0.063	3.00	659	0.116	-0.011	1.99	1.98	-0.001	0.000	1.99	1.98	-0.095	-7.530	0.985	0.114	8.10
	2	0.06	-2.00	659	0.14	-0.002	1.96	1.92	-0.004	-0.001	1.96	1.91	-0.014	-1.611	0.975	0.137	2.57
	3	0.06	-10.00	659	0.025	-0.001	1.84	1.92	-0.003	0.000	1.84	1.93	-0.040	-3.650	0.978	0.024	10.64
	4	0.055	7.00	659	0.032	0.002	1.86	1.93	-0.008	0.000	1.86	1.94	0.063	5.083	0.973	0.031	8.64
5	1	0.055	2.00	659	0.039	-0.001	1.75	1.82	-0.003	0.000	1.75	1.83	-0.026	-2.528	0.976	0.038	3.22
	2	0.053	0.00	659	0.067	0.001	1.92	1.95	-0.006	0.000	1.92	1.96	0.015	0.853	0.973	0.065	0.85
	3	0.052	-5.00	659	0.076	0	1.81	1.84	-0.005	0.000	1.81	1.85	0.000	-0.424	0.974	0.074	5.02
	4	0.05	-9.00	659	0.109	-0.001	1.74	1.74	-0.004	0.000	1.74	1.74	-0.009	-1.191	0.975	0.106	9.08
6	1	0.055	-15.00	659	0.133	0.002	1.94	1.91	-0.006	-0.001	1.94	1.90	0.015	0.862	0.973	0.129	15.02
	2	0.048	0.00	659	0.036	0.006	1.83	1.9	-0.011	0.000	1.83	1.91	0.167	13.867	0.989	0.036	13.87
	3	0.06	2.00	659	0.06	0.019	1.85	1.9	-0.010	-0.001	1.85	1.91	0.317	20.439	1.019	0.061	20.53
	4	0.06	6.00	659	0.067	0.023	2.01	2.06	-0.010	-0.001	2.01	2.07	0.343	20.916	1.022	0.068	21.72
7	1	0.06	12.00	659	0.083	0.024	1.8	1.82	-0.010	-0.001	1.80	1.82	0.289	19.832	1.015	0.084	23.05
	2	0.067	9.00	659	0.095	0.019	2.15	2.16	-0.011	-0.001	2.15	2.16	0.200	16.082	0.997	0.095	18.37
	3	0.072	2.00	659	0.134	0.023	2.37	2.34	-0.011	-0.001	2.37	2.33	0.172	14.223	0.990	0.133	14.36
	4	0.074	-15.00	659	0.153	0.015	2.41	2.36	-0.009	-0.001	2.41	2.35	0.098	8.266	0.976	0.149	17.08
8	1	0.07	6.00	659	0.155	0.05	2.33	2.28	-0.010	-0.002	2.33	2.27	0.323	20.550	1.019	0.158	21.37
	2	0.063	4.00	659	0.146	0.057	2.23	2.19	-0.010	-0.001	2.23	2.18	0.390	21.915	1.029	0.150	22.26
	3	0.061	5.00	659	0.114	0.047	2.11	2.1	-0.010	-0.001	2.11	2.10	0.412	22.662	1.034	0.118	23.18
	4	0.059	5.00	659	0.107	0.046	2.03	2.03	-0.009	-0.001	2.03	2.03	0.430	23.496	1.041	0.111	23.99
9	1	0.057	-5.00	659	0.122	0.049	1.98	1.96	-0.010	-0.001	1.98	1.96	0.402	22.265	1.031	0.126	22.79
	2	0.059	-7.00	659	0.135	0.05	1.97	1.93	-0.010	-0.001	1.97	1.92	0.370	21.425	1.025	0.138	22.49
	3	0.056	-2.00	659	0.136	0.031	1.91	1.88	-0.010	-0.001	1.91	1.87	0.228	17.601	1.003	0.136	17.71
	4	0.055	0.00	659	0.154	0.045	1.78	1.73	-0.010	-0.002	1.78	1.72	0.292	19.908	1.015	0.156	19.91
	37	0.05	-3.00	659	0.124	0.05	1.76	1.74	-0.010	-0.001	1.76	1.74	0.403	22.320	1.032	0.128	22.51
	38	0.052	2.00	659	0.136	0.065	1.83	1.8	-0.009	-0.001	1.83	1.79	0.478	27.297	1.080	0.147	27.36
	39	0.05	2.00	659	0.134	0.062	1.92	1.89	-0.009	-0.001	1.92	1.88	0.463	25.806	1.063	0.142	25.88
	40	0.053	-2.00	659	0.132	0.056	1.82	1.79	-0.009	-0.001	1.82	1.78	0.424	23.201	1.039	0.137	23.28
	41	0.056	-3.00	659	0.122	0.035	1.76	1.74	-0.010	-0.001	1.76	1.74	0.287	19.773	1.015	0.124	19.99
	42	0.054	4.00	659	0.107	0.009	1.45	1.44	-0.009	-0.001	1.45	1.44	0.084	7.028	0.975	0.104	8.08

Avg. Duct Static = 1.89

Yaw Avg. = 0.93	Average Temp.
Std. Dev. = 6.73	659

Pitch Avg. = 3.29	Result Angle Avg. = 18.31
Std. Dev. = 18.63	Std. Dev. = 7.71

IP7_037049

IP7_0370050

OFA SW ONE THIRD OPEN 4-2-03

Traverse Point Velocity	Probes Point Velocity
20.92	25.07
22.30	24.62
23.75	24.41
25.61	25.54
26.56	24.87
29.09	24.87
33.55	25.52
15.99	25.74
19.02	25.96
24.24	25.96
26.97	25.96
31.04	25.96
35.45	26.60
39.12	25.96
16.28	25.96
18.49	24.85
20.65	24.86
27.06	24.40
28.73	24.17
34.12	23.70
36.83	24.85
19.41	23.22
24.54	25.96
25.75	25.95
28.31	25.96
30.93	27.42
37.36	28.42
39.12	28.81
39.21	28.02
37.99	26.59
33.44	26.17
32.31	25.74
34.65	25.30
36.43	25.74
37.29	25.08
39.41	24.86
35.02	23.70
36.07	24.17
35.99	23.70
36.05	24.40
35.05	25.08
33.91	24.64

Traverse	Probes
Avg. Velocity in ft/s	
30.10	25.45

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		659				
AVERAGE PRESSURE IN. W.C. (Pg)		1.89				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.14	25.14	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	30.10	25.45	
ACTUAL STACK VOLUME (Q acfm) =	106,839	90,335	-15.45
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	42,356	35,813	-15.45
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	42,356	35,813	-15.45
FLOW IN LBS/HR (wet) =	190937	161442	-15.45
FLOW IN LBS/HR (dry) =	190937	161442	-15.45

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029786
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.056	5.00	659	0.046	-0.02	2.01	2.07	-0.004	0.000	2.01	2.08	-0.435	-28.285	1.102	0.051	28.69
	2	0.054	3.00	659	0.051	-0.02	1.95	2.01	-0.002	0.000	1.95	2.02	-0.392	-25.644	1.071	0.055	25.81
	3	0.053	-12.00	659	0.057	-0.038	1.5	1.57	0.000	0.000	1.50	1.58	-0.667	-17.951	1.016	0.058	21.48
	4	0.058	-3.00	659	0.068	-0.04	1.34	1.36	-0.003	0.000	1.34	1.36	-0.588	-27.362	1.090	0.074	27.51
2	1	0.055	3.00	659	0.075	-0.038	1.43	1.37	-0.005	0.000	1.43	1.36	-0.507	-30.671	1.133	0.085	30.80
	2	0.055	7.00	659	0.085	-0.028	1.44	1.36	0.000	0.000	1.44	1 35	-0.329	-21.353	1.035	0.088	22.42
	3	0.058	1.00	659	0.104	-0.012	1.97	1.97	0.000	0.000	1.97	1.97	-0.115	-8.828	0.987	0.103	8.88
	4	0.059	13.00	659	0.027	-0.017	1.77	1.85	-0.001	0.000	1.77	1.86	-0.630	-22.840	1.046	0.028	26.11
3	1	0.06	2.00	659	0.036	-0.023	1.82	1.89	-0.001	0.000	1.82	1.90	-0.639	-21.645	1.037	0.037	21.73
	2	0.06	6.00	659	0.06	-0.022	1.88	1.93	-0.002	0.000	1.88	1.94	-0.367	-23.906	1.055	0.063	24.60
	3	0.06	11.00	659	0.073	-0.02	1.87	1.9	0.001	0.000	1.87	1.91	-0.274	-17.800	1.016	0.074	20.83
	4	0.06	10.00	659	0.094	-0.02	1.92	1.93	0.001	0.000	1.92	1.93	-0.213	-14.305	1.002	0.094	17.39
4	1	0.063	3.00	659	0.116	-0.011	1.99	1.98	-0.001	0.000	1.99	1.98	-0.095	-7.530	0.985	0.114	8.10
	2	0.06	-2.00	659	0.14	-0.002	1.96	1.92	-0.004	-0.001	1.96	1.91	-0.014	-1.611	0.975	0.137	2.57
	3	0.06	-10.00	659	0.025	-0.001	1.84	1.92	-0.003	0.000	1.84	1.93	-0.040	-3.650	0.978	0.024	10.64
	4	0.055	7.00	659	0.032	0.002	1.86	1.93	-0.008	0.000	1.86	1.94	0.063	5.083	0.973	0.031	8.64
5	1	0.055	2.00	659	0.039	-0.001	1.75	1.82	-0.003	0.000	1.75	1.83	-0.026	-2.528	0.976	0.038	3.22
	2	0.053	0.00	659	0.067	0.001	1.92	1.95	-0.006	0.000	1.92	1.96	0.015	0.853	0.973	0.065	0.85
	3	0.052	-5.00	659	0.076	0	1.81	1.84	-0.005	0.000	1.81	1.85	0.000	-0.424	0.974	0.074	5.02
	4	0.05	-9.00	659	0.109	-0.001	1.74	1.74	-0.004	0.000	1.74	1.74	-0.009	-1.191	0.975	0.106	9.08
6	1	0.055	-15.00	659	0.133	0.002	1.94	1.91	-0.006	-0.001	1.94	1.90	0.015	0.862	0.973	0.129	15.02
	2	0.048	0.00	659	0.036	0.006	1.83	1.9	-0.011	0.000	1.83	1.91	0.167	13.867	0.989	0.036	13.87
	3	0.06	2.00	659	0.06	0.019	1.85	1.9	-0.010	-0.001	1.85	1.91	0.317	20.439	1.019	0.061	20.53
	4	0.06	6.00	659	0.067	0.023	2.01	2.06	-0.010	-0.001	2.01	2.07	0.343	20.916	1.022	0.068	21.72
7	1	0.06	12.00	659	0.083	0.024	1.8	1.82	-0.010	-0.001	1.80	1.82	0.289	19.832	1.015	0.084	23.05
	2	0.067	9.00	659	0.095	0.019	2.15	2.16	-0.011	-0.001	2.15	2.16	0.200	16.082	0.997	0.095	18.37
	3	0.072	2.00	659	0.134	0.023	2.37	2.34	-0.011	-0.001	2.37	2.33	0.172	14.223	0.990	0.133	14.36
	4	*0.074*	*-15.00*	659	*0.153*	*0.015*	*2.41*	*2.36*	*-0.009*	*-0.001*	*2.41*	*2.35*	*0.098*	*8.266*	*0.976*	*0.149*	*17.08*
8	1	0.07	6.00	659	0.155	0.05	2.33	2.28	-0.010	-0.002	2.33	2.27	0.323	20.550	1.019	0.158	21.37
	2	0.063	4.00	659	0.146	0.057	2.23	2.19	-0.010	-0.001	2.23	2.18	0.390	21.915	1.029	0.150	22.26
	3	0.061	5.00	659	0.114	0.047	2.11	2.1	-0.010	-0.001	2.11	2.10	0.412	22.662	1.034	0.118	23.18
	4	0.059	5.00	659	0.107	0.046	2.03	2.03	-0.009	-0.001	2.03	2.03	0.430	23.496	1.041	0.111	23.99
9	1	0.057	-5.00	659	0.122	0.049	1.98	1.96	-0.010	-0.001	1.98	1.96	0.402	22.265	1.031	0.126	22.79
	2	0.059	-7.00	659	0.135	0.05	1.97	1.93	-0.010	-0.001	1.97	1.92	0.370	21.425	1.025	0.138	22.49
	3	0.056	-2.00	659	0.136	0.031	1.91	1.88	-0.010	-0.001	1.91	1.87	0.228	17.601	1.003	0.136	17.71
	4	0.055	0.00	659	0.154	0.045	1.78	1.73	-0.010	-0.002	1.78	1.72	0.292	19.908	1.015	0.156	19.91
	37	0.05	-3.00	659	0.124	0.05	1.76	1.74	-0.010	-0.001	1.76	1.74	0.403	22.320	1.032	0.128	22.51
	38	0.052	2.00	659	0.136	0.065	1.83	1.8	-0.009	-0.001	1.83	1.79	0.478	27.297	1.080	0.147	27.36
	39	0.05	2.00	659	0.134	0.062	1.92	1.89	-0.009	-0.001	1.92	1.88	0.463	25.806	1.063	0.142	25.88
	40	0.053	-2.00	659	0.132	0.056	1.82	1.79	-0.009	-0.001	1.82	1.78	0.424	23.201	1.039	0.137	23.28
	41	0.056	-3.00	659	0.122	0.035	1.76	1.74	-0.010	-0.001	1.76	1.74	0.287	19 773	1.015	0.124	19.99
	42	0.054	4.00	659	0.107	0.009	1.45	1.44	-0.009	-0.001	1.45	1.44	0.084	7.028	0.975	0.104	8.08

Avg. Duct Static = 1.89

Yaw Avg. = 0.93
Std. Dev. = 6.73

Average Temp. 659

Pitch Avg. = 3.29
Std. Dev. = 18.63

Result Angle Avg. = 18.31
Std. Dev. = 7.71

Traverse Point Velocity	Probes Point Velocity
20.92	25.07
22.30	24.62
23.75	24.41
25.61	25.54
26.56	24.87
29.09	24.87
33.55	25.52
15.99	25.74
19.02	25.96
24.24	25.96
26.97	25.96
31.04	25.96
35.45	26.60
39.12	25.96
16.28	25.96
18.49	24.85
20.65	24.86
27.06	24.40
28.73	24.17
34.12	23.70
36.83	24.85
19.41	23.22
24.54	25.96
25.75	25.95
28.31	25.96
30.93	27.42
37.36	28.42
39.12	28.81
39.21	28.02
37.99	26.59
33.44	26.17
32.31	25.74
34.65	25.30
36.43	25.74
37.29	25.08
39.41	24.86
35.02	23.70
36.07	24.17
35.99	23.70
36.05	24.40
35.05	25.08
33.91	24.64

Traverse	Probes
Avg. Velocity in ft/s	
30.10	25.45

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain**
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		685				
AVERAGE PRESSURE IN. W.C. (Pg)		1.68				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.12	25.12	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	52.71	47.30	
ACTUAL STACK VOLUME (Q acfm) =	187,118	167,904	-10.27
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	72,470	65,028	-10.27
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	72,470	65,028	-10.27
FLOW IN LBS/HR (wet) =	326688	293141	-10.27
FLOW IN LBS/HR (dry) =	326688	293141	-10.27

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029098
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.198	10.00	675	0.101	-0.05	1.56	1.56	-0.005	-0.001	1.56	1.56	-0.495	-30 553	1.132	0.114	32.00
	2	0.193	10.00	685	0.137	-0.096	1.7	1.66	0.001	0.000	1.70	1.65	-0.701	-14.119	1.001	0.137	17.24
	3	0.192	15.00	685	0.168	-0.105	1.83	1.76	-0.001	0.000	1.83	1.75	-0.625	-23.419	1.051	0.177	27.58
	4	0.192	3.00	685	0.176	-0.1	1.87	1.79	-0.004	-0.001	1.87	1.78	-0.568	-28.899	1.109	0.195	29.04
2	1	0.193	0.00	685	0.208	-0.105	1.87	1.76	-0 005	-0.001	1.87	1.74	-0.505	-30.661	1.133	0.236	30.66
	2	0.193	4.00	685	0.255	-0.075	1.92	1.76	0.000	0.000	1.92	1.73	-0.294	-19.045	1.022	0.261	19.45
	3	0.201	-5.00	685	0.309	-0.035	1.98	1.77	0.000	0.000	1.98	1.73	-0.113	-8.698	0.987	0.305	10.02
	4	0.198	-4.00	685	0.098	-0.052	1.6	1.6	-0.005	-0.001	1.60	1.60	-0.531	-30.489	1.131	0.111	30.72
3	1	0.202	14.00	685	0.111	-0.042	1.62	1.61	-0.002	0.000	1.62	1.61	-0.378	-24.711	1.062	0.118	28.18
	2	0.191	13.00	685	0.127	-0.034	1.62	1.59	0.001	0.000	1.62	1.58	-0.268	-17.424	1.014	0.129	21.62
	3	0.194	9.00	685	0.174	-0.037	1.7	1.63	0.001	0.000	1.70	1.62	-0.213	-14.298	1.002	0.174	16.84
	4	0.192	-3.00	685	0.231	-0.038	1.79	1.66	0.000	0.000	1.79	1.64	-0.165	-11.672	0.994	0.230	12.05
4	1	0.192	-4.00	685	0.295	-0.024	1.86	1.67	-0.001	0.000	1.86	1.64	-0.081	-6.636	0.983	0.290	7.74
	2	0.194	-3.00	685	0.377	-0.009	2.08	1.8	-0.004	-0.001	2.08	1.75	-0.024	-2.387	0.976	0.368	3.83
	3	0.199	-2.00	685	0.147	0.009	1.87	1.82	-0.008	-0.001	1.87	1.81	0.061	4.968	0.973	0.143	5.35
	4	0.195	1.00	685	0.156	0.013	1.85	1.79	-0.009	-0.001	1.85	1.78	0.083	6.958	0 975	0.152	7.03
5	1	0.194	4.00	685	0.143	0.011	1.84	1.8	-0.009	-0.001	1.84	1.79	0.077	6 382	0.974	0.139	7.53
	2	0.195	5.00	685	0.143	0.015	1.82	1.78	-0.010	-0.001	1.82	1.77	0.105	8 868	0.977	0.140	10.17
	3	0.198	0.00	685	0.214	0.013	1.91	1.79	-0.008	-0.002	1.91	1.77	0.061	4.925	0.973	0.208	4.93
	4	0.192	-7.00	685	0.304	0.009	1.95	1.74	-0.006	-0.002	1.95	1.70	0.030	2.138	0.973	0.296	7.32
6	1	0.195	-12.00	685	0.373	0.013	2.04	1.76	-0.007	-0.002	2.04	1.71	0.035	2.603	0.973	0.363	12.27
	2	0.192	-1.00	685	0.278	0.052	1.84	1.66	-0.011	-0.003	1.84	1.63	0.187	15.271	0.993	0.276	15.30
	3	0.196	1.00	685	0.227	0.061	1.84	1.72	-0.010	-0.002	1.84	1.70	0.269	19.243	1.012	0.230	19.27
	4	0.196	4.00	685	0.226	0.061	1.88	1.75	-0.010	-0.002	1.88	1.73	0.270	19.281	1.012	0.229	19.68
7	1	0.199	-1.00	685	0.237	0.064	1.9	1.76	-0.010	-0.002	1.90	1.74	0.270	19.285	1.012	0.240	19.31
	2	0.198	-3.00	685	0.259	0.06	1.99	1.84	-0.010	-0.003	1.99	1.81	0.232	17.779	1.004	0.260	18.02
	3	0.197	-20.00	685	0.307	0.057	1.74	1.53	-0.011	-0.003	1.74	1.49	0.186	15.180	0.993	0.305	24.92
	4	0.198	-20.00	685	0.357	0.039	2.05	1.79	-0.010	-0.003	2.05	1.74	0.109	9.247	0.978	0.349	21.95
8	1	0.186	6.00	685	0.417	0.1	2.02	1.69	-0.010	-0.004	2.02	1.63	0.240	18.148	1.006	0.419	19.08
	2	0.191	0.00	685	0.395	0.101	2	1.69	-0.010	-0.004	2.00	1.64	0.256	18.790	1.009	0.399	18.79
	3	0.193	3.00	685	0.354	0.113	2.05	1.8	-0.010	-0.004	2.05	1.76	0.319	20.487	1.019	0.361	20.70
	4	0.191	-3.00	685	0.382	0.123	2.1	1.81	-0.010	-0.004	2.10	1.76	0.322	20.539	1.019	0.389	20.75
9	1	0.193	2.00	685	0.392	0.124	1.97	1.66	-0.010	-0.004	1.97	1.61	0.316	20.433	1.019	0.399	20.53
	2	0.197	-3.00	685	0.4	0.114	1.96	1.66	-0.010	-0.004	1.96	1.61	0.285	19.723	1.014	0.406	19.94
	3	0.197	0.00	685	0.385	0.071	1.99	1.7	-0.011	-0.004	1.99	1.65	0.184	15.098	0.993	0.382	15.10
	4	0.198	4.00	685	0.459	0.084	1.97	1.6	-0.011	-0.005	1.97	1.54	0.183	15.004	0.992	0.456	15.52
	37	0.192	4.00	685	0.45	0.101	2.04	1.68	-0.010	-0.005	2.04	1.62	0.224	17.429	1.002	0.451	17.87
	38	0.193	8.00	685	0.445	0.128	2.01	1.66	-0.010	-0.005	2.01	1.60	0.288	19.793	1.015	0.452	21.29
	39	0.198	4.00	685	0.439	0.132	2.15	1.8	-0.010	-0.004	2.15	1.74	0.301	20.108	1.017	0.446	20.49
	40	0.198	2.00	685	0.415	0.113	2.08	1.75	-0.010	-0.004	2.08	1.69	0 272	19.356	1.012	0.420	19.46
	41	0.189	0.00	685	0.35	0.078	1.94	1.68	-0.010	-0.004	1.94	1.63	0.223	17.349	1.002	0.351	17.35
	42	0.188	2.00	685	0.284	0.014	1.83	1.65	-0.007	-0.002	1.83	1.62	0.049	3.894	0.973	0.276	4.38

-12.00

Avg. Duct Static = 1.68

Yaw Avg. = 0.88	Average Temp.
Std. Dev. = 7.31	685

Pitch Avg. = 3.22	Result Angle Avg. = 17.41
Std. Dev. = 17.44	Std. Dev. = 7.55

IP7_037057

IP7_0037058

OFA SW BOTH DAMPERS OPEN 4-2-03

Traverse Point Velocity	Probes Point Velocity
30.62	47.52
37.94	47.11
39.93	46.98
41.42	46.98
44.78	47.11
51.61	47.11
58.31	48.07
30.69	47.72
32.46	48.20
35.78	46.87
42.86	47.24
50.26	46.99
57.22	46.99
64.90	47.23
40.38	47.83
41.49	47.35
39.67	47.22
39.45	47.35
48.75	47.71
57.84	46.99
63.12	47.35
54.36	46.99
48.51	47.47
48.28	47.47
49.55	47.83
51.99	47.71
53.71	47.61
58.75	47.71
65.64	46.25
64.10	46.87
60.24	47.10
62.57	46.86
63.47	47.11
64.22	47.60
64.01	47.60
69.75	47.73
68.55	46.99
67.15	47.12
67.10	47.71
65.53	47.72
60.62	46.62
56.21	46.50

Traverse	Probes
Avg. Velocity in ft/s	
52.71	47.30

IP7_037059

3D PROBE WORK SHEET

PROJECT:--- **Inter-Mountain** **OFA SW**
Date:.... **4/2/2003**
Load:...... **Damper 1/3**

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		659				
AVERAGE PRESSURE IN. W.C. (Pg)		1.94				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.14	25.14	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	30.10	25.44	
ACTUAL STACK VOLUME (Q acfm) =	106,851	90,328	-15.46
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	42,368	35,816	-15.46
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	42,368	35,816	-15.46
FLOW IN LBS/HR (wet) =	190991	161455	-15.46
FLOW IN LBS/HR (dry) =	190991	161455	-15.46

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029791
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037060

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.056	5.00	659	0.046	-0.02	2.01	2.07	-0.004	0.000	2.01	2.08	-0.435	-28.285	1.102	0.051	28.69
	2	0.054	3.00	659	0.051	-0.02	1.95	2.01	-0.002	0.000	1.95	2.02	-0.392	-25.644	1.071	0.055	25.81
	3	0.053	11.00	659	0.057	-0.038	1.92	1.96	0.000	0.000	1.92	1.97	-0.667	-17.951	1.016	0.058	20.96
	4	0.058	4.00	659	0.068	-0.04	1.9	1.94	-0.003	0.000	1.90	1.95	-0.588	-27.362	1.090	0.074	27.63
	5	0.055	5.00	659	0.075	-0.038	1.75	1.78	-0.005	0.000	1.75	1.79	-0.507	-30.671	1.133	0.085	31.04
	6	0.055	-2.00	659	0.085	-0.028	1.82	1.84	0.000	0.000	1.82	1.84	-0.329	-21.353	1.035	0.088	21.44
	7	0.058	1.00	659	0.104	-0.012	1.97	1.97	0.000	0.000	1.97	1 97	-0.115	-8.828	0.987	0.103	8.88
2	1	0.059	13.00	659	0.027	-0.017	1.77	1.85	-0.001	0.000	1.77	1.86	-0.630	-22.840	1.046	0.028	26.11
	2	0.06	2.00	659	0.036	-0.023	1.82	1.89	-0.001	0.000	1.82	1.90	-0.639	-21.645	1.037	0.037	21.73
	3	0.06	6.00	659	0.06	-0.022	1.88	1.93	-0.002	0.000	1.88	1.94	-0.367	-23.906	1.055	0.063	24.60
	4	0.06	11.00	659	0.073	-0.02	1.87	1.9	0.001	0.000	1.87	1.91	-0.274	-17.800	1.016	0.074	20.83
	5	0.06	10.00	659	0.094	-0.02	1.92	1.93	0.001	0.000	1.92	1.93	-0.213	-14.305	1.002	0.094	17.39
	6	0.063	3.00	659	0.116	-0.011	1.99	1.98	-0.001	0.000	1.99	1 98	-0.095	-7.530	0.985	0.114	8.10
	7	0.06	-2.00	659	0.14	-0.002	1.96	1.92	-0.004	-0.001	1.96	1.91	-0.014	-1.611	0.975	0.137	2.57
3	1	0.06	-10.00	659	0.025	-0.001	1.84	1.92	-0.003	0.000	1.84	1.93	-0.040	-3.650	0.978	0.024	10.64
	2	0.055	7.00	659	0.032	0.002	1.86	1.93	-0.008	0.000	1.86	1.94	0.063	5.083	0.973	0.031	8.64
	3	0.055	2.00	659	0.039	-0.001	1.75	1.82	-0.003	0.000	1.75	1 83	-0.026	-2.528	0.976	0.038	3.22
	4	0.053	0.00	659	0.067	0.001	1.92	1.95	-0.006	0.000	1.92	1.96	0.015	0 853	0.973	0.065	0.85
	5	0.052	-5.00	659	0.076	0	1.81	1.84	-0.005	0.000	1.81	1.85	0.000	-0.424	0.974	0.074	5.02
	6	0.05	-9.00	659	0.109	-0.001	1.74	1.74	-0.004	0.000	1.74	1.74	-0.009	-1.191	0.975	0.106	9.08
	7	0.055	-15.00	659	0.133	0.002	1.94	1.91	-0.006	-0.001	1.94	1.90	0.015	0 862	0.973	0.129	15.02
4	1	0.048	0.00	659	0.036	0.006	1.83	1.9	-0.011	0.000	1.83	1.91	0.167	13.867	0.989	0.036	13.87
	2	0.06	2.00	659	0.06	0.019	1.85	1.9	-0.010	-0.001	1.85	1.91	0.317	20.439	1.019	0.061	20.53
	3	0.06	6.00	659	0.067	0.023	2.01	2.06	-0.010	-0.001	2.01	2.07	0.343	20.916	1.022	0.068	21.72
	4	0.06	12.00	659	0.083	0.024	1.8	1.82	-0.010	-0.001	1.80	1.82	0.289	19.832	1.015	0.084	23.05
	5	0.067	9.00	659	0.095	0.019	2.15	2.16	-0.011	-0.001	2.15	2.16	0.200	16.082	0.997	0.095	18.37
	6	0.072	2.00	659	0.134	0.023	2.37	2.34	-0.011	-0.001	2.37	2.33	0.172	14.223	0.990	0.133	14.36
	7	0.074	-15.00	659	0.153	0.015	2.41	2.36	-0.009	-0.001	2.41	2.35	0.098	8.266	0.976	0.149	17.08
5	1	0.07	6.00	659	0.155	0.05	2.33	2.28	-0.010	-0.002	2.33	2.27	0.323	20.550	1.019	0.158	21.37
	2	0.063	4.00	659	0.146	0.057	2.23	2.19	-0.010	-0.001	2.23	2.18	0.390	21.915	1.029	0.150	22.26
	3	0.061	5.00	659	0.114	0.047	2.11	2.1	-0.010	-0.001	2.11	2.10	0.412	22.662	1.034	0.118	23.18
	4	0.059	5.00	659	0.107	0.046	2.03	2.03	-0.009	-0.001	2.03	2.03	0.430	23.496	1.041	0.111	23.99
	5	0.057	-5.00	659	0.122	0.049	1.98	1.96	-0.010	-0.001	1.98	1.96	0.402	22.265	1.031	0.126	22.79
	6	0.059	-7.00	659	0.135	0.05	1.97	1.93	-0.010	-0.001	1.97	1.92	0.370	21.425	1.025	0.138	22.49
	7	0.056	-2.00	659	0.136	0.031	1.91	1.88	-0.010	-0.001	1.91	1.87	0.228	17.601	1.003	0.136	17.71
6	1	0.055	0.00	659	0.154	0.045	1.78	1.73	-0.010	-0.002	1.78	1.72	0.292	19.908	1.015	0.156	19.91
	2	0.05	-3.00	659	0.124	0.05	1.76	1.74	-0.010	-0.001	1.76	1.74	0.403	22.320	1.032	0.128	22.51
	3	0.052	2.00	659	0.136	0.065	1.83	1.8	-0.009	-0.001	1.83	1.79	0.478	27.297	1.080	0.147	27.36
	4	0.05	2.00	659	0.134	0.062	1.92	1.89	-0.009	-0.001	1.92	1.88	0.463	25.806	1.063	0.142	25.88
	5	0.053	-2.00	659	0.132	0.056	1.82	1.79	-0.009	-0.001	1.82	1 78	0.424	23.201	1.039	0.137	23.28
	6	0.056	-3.00	659	0.122	0.035	1.76	1.74	-0.010	-0.001	1.76	1.74	0.287	19.773	1.015	0.124	19.99
	7	0.054	3.00	659	0.107	0.009	1.89	1.89	-0.009	-0.001	1.89	1.89	0.084	7.028	0.975	0.104	7.64

Avg. Duct Static = 1 94

Yaw Avg. = 1.45	Average Temp.
Std. Dev. = 6.54	659

Pitch Avg. = 3.29	Result Angle Avg. = 18.28
Std. Dev. = 18.63	Std. Dev. = 7.72

IP7_037061

Traverse Point Velocity	Probes Point Velocity
20.92	25.07
22.30	24.62
23.82	24.39
25.56	25.52
26.48	24.86
29.27	24.86
33.55	25.52
15.99	25.74
19.02	25.96
24.24	25.96
26.97	25.96
31.04	25.96
35.45	26.60
39.12	25.96
16.28	25.96
18.49	24.85
20.65	24.86
27.06	24.40
28.73	24.17
34.12	23.70
36.83	24.85
19.41	23.22
24.54	25.96
25.75	25.95
28.31	25.96
30.93	27.42
37.36	28.42
39.12	28.81
39.21	28.02
37.99	26.59
33.44	26.17
32.31	25.74
34.65	25.30
36.43	25.74
37.29	25.08
39.41	24.86
35.02	23.70
36.07	24.17
35.99	23.70
36.05	24.40
35.05	25.08
33.92	24.63

Traverse	Probes
Avg. Velocity in ft/s	
30.10	25.44

IP7_037063

3D PROBE WORK SHEET

PROJECT:--- Inter-Mountain
Date:....
Load:......

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	71.000	120.000	71.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		685				
AVERAGE PRESSURE IN. W.C. (Pg)		1.68				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.00				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.12	25.12	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	59.167	59.167	
STACK VELOCITY FT/ SEC. (Vs) =	52.71	47.30	
ACTUAL STACK VOLUME (Q acfm) =	187,118	167,904	-10.27
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	72,470	65,028	-10.27
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	72,470	65,028	-10.27
FLOW IN LBS/HR (wet) =	326688	293141	-10.27
FLOW IN LBS/HR (dry) =	326688	293141	-10.27

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029098
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037064

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees
1	1	0.198	10.00	675	0.101	-0.05	1.56	1.56	-0.005	-0.001	1.56	1.56	-0.495	-30.553	1.132	0.114	32.00
	2	0.193	10.00	685	0.137	-0.096	1.7	1.66	0.001	0.000	1.70	1.65	-0.701	-14.119	1.001	0.137	17.24
	3	0.192	15.00	685	0.168	-0.105	1.83	1.76	-0.001	0.000	1.83	1.75	-0.625	-23.419	1.051	0.177	27.58
	4	0.192	3.00	685	0.176	-0.1	1.87	1.79	-0.004	-0.001	1.87	1.78	-0.568	-28.899	1.109	0.195	29.04
2	1	0.193	0.00	685	0.208	-0.105	1.87	1.76	-0.005	-0.001	1.87	1.74	-0.505	-30.661	1.133	0.236	30.66
	2	0.193	4.00	685	0.255	-0.075	1.92	1.76	0.000	0.000	1.92	1.73	-0.294	-19.045	1.022	0.261	19.45
	3	0.201	-5.00	685	0.309	-0.035	1.98	1.77	0.000	0.000	1.98	1.73	-0.113	-8.698	0.987	0.305	10.02
	4	0.198	-4.00	685	0.098	-0.052	1.6	1.6	-0.005	-0.001	1.60	1.60	-0.531	-30.489	1.131	0.111	30.72
3	1	0.202	14.00	685	0.111	-0.042	1.62	1.61	-0.002	0.000	1.62	1.61	-0.378	-24.711	1.062	0.118	28.18
	2	0.191	13.00	685	0.127	-0.034	1.62	1.59	0.001	0.000	1.62	1.58	-0.268	-17.424	1.014	0.129	21.62
	3	0.194	9.00	685	0.174	-0.037	1.7	1.63	0.001	0.000	1.70	1.62	-0.213	-14.298	1.002	0.174	16.84
	4	0.192	-3.00	685	0.231	-0.038	1.79	1.66	0.000	0.000	1.79	1.64	-0.165	-11.672	0.994	0.230	12.05
4	1	0.192	-4.00	685	0.295	-0.024	1.86	1.67	-0.001	0.000	1.86	1.64	-0.081	-6.636	0.983	0.290	7.74
	2	0.194	-3.00	685	0.377	-0.009	2.08	1.8	-0.004	-0.001	2.08	1.75	-0.024	-2.387	0.976	0.368	3.83
	3	0.199	-2.00	685	0.147	0.009	1.87	1.82	-0.008	-0.001	1.87	1.81	0.061	4.968	0.973	0.143	5.35
	4	0.195	1.00	685	0.156	0.013	1.85	1.79	-0.009	-0.001	1.85	1.78	0.083	6.958	0.975	0.152	7.03
5	1	0.194	4.00	685	0.143	0.011	1.84	1.8	-0.009	-0.001	1.84	1.79	0.077	6.382	0.974	0.139	7.53
	2	0.195	5.00	685	0.143	0.015	1.82	1.78	-0.010	-0.001	1.82	1.77	0.105	8.868	0.977	0.140	10.17
	3	0.198	0.00	685	0.214	0.013	1.91	1.79	-0.008	-0.002	1.91	1.77	0.061	4.925	0.973	0.208	4.93
	4	0.192	-7.00	685	0.304	0.009	1.95	1.74	-0.006	-0.002	1.95	1.70	0.030	2.138	0.973	0.296	7.32
6	1	0.195	-12.00	685	0.373	0.013	2.04	1.76	-0.007	-0.002	2.04	1.71	0.035	2.603	0.973	0.363	12.27
	2	0.192	-1.00	685	0.278	0.052	1.84	1.66	-0.011	-0.003	1.84	1.63	0.187	15.271	0.993	0.276	15.30
	3	0.196	1.00	685	0.227	0.061	1.84	1.72	-0.010	-0.002	1.84	1.70	0.269	19.243	1.012	0.230	19.27
	4	0.196	4.00	685	0.226	0.061	1.88	1.75	-0.010	-0.002	1.88	1.73	0.270	19.281	1.012	0.229	19.68
7	1	0.199	-1.00	685	0.237	0.064	1.9	1.76	-0.010	-0.002	1.90	1.74	0.270	19.285	1.012	0.240	19.31
	2	0.198	-3.00	685	0.259	0.06	1.99	1.84	-0.010	-0.003	1.99	1.81	0.232	17.779	1.004	0.260	18.02
	3	0.197	-20.00	685	0.307	0.057	1.74	1.53	-0.011	-0.003	1.74	1.49	0.186	15.180	0.993	0.305	24.92
	4	0.198	-20.00	685	0.357	0.039	2.05	1.79	-0.010	-0.003	2.05	1.74	0.109	9.247	0.978	0.349	21.95
8	1	0.186	6.00	685	0.417	0.1	2.02	1.69	-0.010	-0.004	2.02	1.63	0.240	18.148	1.006	0.419	19.08
	2	0.191	0.00	685	0.395	0.101	2	1.69	-0.010	-0.004	2.00	1.64	0.256	18.790	1.009	0.399	18.79
	3	0.193	3.00	685	0.354	0.113	2.05	1.8	-0.010	-0.004	2.05	1.76	0.319	20.487	1.019	0.361	20.70
	4	0.191	-3.00	685	0.382	0.123	2.1	1.81	-0.010	-0.004	2.10	1.76	0.322	20.539	1.019	0.389	20.75
9	1	0.193	2.00	685	0.392	0.124	1.97	1.66	-0.010	-0.004	1.97	1.61	0.316	20.433	1.019	0.399	20.53
	2	0.197	-3.00	685	0.4	0.114	1.96	1.66	-0.010	-0.004	1.96	1.61	0.285	19.723	1.014	0.406	19.94
	3	0.197	0.00	685	0.385	0.071	1.99	1.7	-0.011	-0.004	1.99	1.65	0.184	15.098	0.993	0.382	15.10
	4	0.198	4.00	685	0.459	0.084	1.97	1.6	-0.011	-0.005	1.97	1.54	0.183	15.004	0.992	0.456	15.52
	37	0.192	4.00	685	0.45	0.101	2.04	1.68	-0.010	-0.005	2.04	1.62	0.224	17.429	1.002	0.451	17.87
	38	0.193	8.00	685	0.445	0.128	2.01	1.66	-0.010	-0.005	2.01	1.60	0.288	19.793	1.015	0.452	21.29
	39	0.198	4.00	685	0.439	0.132	2.15	1.8	-0.010	-0.004	2.15	1.74	0.301	20.108	1.017	0.446	20.49
	40	0.198	2.00	685	0.415	0.113	2.08	1.75	-0.010	-0.004	2.08	1.69	0.272	19.356	1.012	0.420	19.46
	41	0.189	0.00	685	0.35	0.078	1.94	1.68	-0.010	-0.004	1.94	1.63	0.223	17.349	1.002	0.351	17.35
	42	0.188	2.00	685	0.284	0.014	1.83	1.65	-0.007	-0.002	1.83	1.62	0.049	3.894	0.973	0.276	4.38

-12.00

Avg. Duct Static = 1.68

Yaw Avg. = 0.88	Average Temp.
Std. Dev. = 7.31	685

Pitch Avg. = 3.22	Result Angle Avg. = 17.41
Std. Dev. = 17.44	Std. Dev. = 7.55

IP7_037065

Traverse Point Velocity	Probes Point Velocity
30.62	47.52
37.94	47.11
39.93	46.98
41.42	46.98
44.78	47.11
51.61	47.11
58.31	48.07
30.69	47.72
32.46	48.20
35.78	46.87
42.86	47.24
50.26	46.99
57.22	46.99
64.90	47.23
40.38	47.83
41.49	47.35
39.67	47.22
39.45	47.35
48.75	47.71
57.84	46.99
63.12	47.35
54.36	46.99
48.51	47.47
48.28	47.47
49.55	47.83
51.99	47.71
53.71	47.61
58.75	47.71
65.64	46.25
64.10	46.87
60.24	47.10
62.57	46.86
63.47	47.11
64.22	47.60
64.01	47.60
69.75	47.73
68.55	46.99
67 15	47.12
67.10	47.71
65.53	47.72
60.62	46.62
56.21	46.50

Traverse	Probes
Avg. Velocity in ft/s	
52.71	47.30

IP7_037067

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: Intermountain Power
WORK ORDER: ______ *REV:* ______
TAG(S): ______

Given Information:

Fluid:	AIR		% H_2O (by volume):		
Standard Temperature (T_{std}):	68	(deg. F)		0.00	(%, by volume)
Standard Barometric Pressure (P_{std}):	29.921	(in. Hg)			
Air Temperature (T):	680	**(deg. F)**	**Maximum Flow:**		
Stack/Duct Pressure (P_g):	0.00	(in. w.c.)		387,000	(lb/hr)
Actual Barometric Pressure (P_{bar}):	25.000	**(in. Hg)**		Wet	(Wet/Dry)
Air Density at Standard Conditions, DRY:	0.07513	(lbs/ft^3)			
Duct Shape:	RECT		Square Root Extraction? (Yes/No)		
Duct Height:	75.000	**(in.)**		Yes	
Duct Width:	120.000	**(in.)**			
			Output:	4-20 mADC	

Calculations:

Duct Area (A_s):	62.500	(ft^2)
Maximum Actual Velocity:	3,550	(AFPM)
Absolute Duct Pressure (P_s):	25.000	(in. Hg)
Dry Mole Fraction of Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.02907	(lbs/ft^3)

NOTE: Due to the large positive bias, the DP is completely offset at lower flows (hence no DP).

Gain:	0.85
% Bias:	14.31
K-Factor:	ON

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
		4.00	0	0	0	0	0
		4.00	22,184	8,585	8,585	38,700	38,700
		4.00	44,369	17,170	17,170	77,400	77,400
		4.00	66,553	25,755	25,755	116,100	116,100
40	0.0060	10.40	88,738	34,340	34,340	154,800	154,800
50	0.0383	12.00	110,924	42,926	42,926	193,500	193,500
60	0.0776	13.60	133,109	51,511	51,511	232,200	232,200
70	0.1241	15.20	155,293	60,096	60,096	270,900	270,900
80	0.1778	16.80	177,478	68,681	68,681	309,600	309,600
90	0.2386	18.40	199,662	77,266	77,266	348,300	348,300
100	0.3066	20.00	221,846	85,851	85,851	387,000	387,000

Transmitter:	CAMM	Power (voltage/type):	24VAC
Flow Element:	VOLU-probe/SS w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0-387,000 lbs/hr	Square Root:	ON
Temperature Range:	0 to 700deg.	Density Compensation:	ON
Pressure Comp. Range:	?		

Temperature Sensor: Single-Pt. Type "E" T/C Probe with panel-mounted 4-20mADC temperature transmitter.

Display Line #1:	0-387,000 lbs/hr	(FLOW)
Display Line #2:	0 to 700deg.	(TEMPERATURE)
Display Line #3:	?	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to .7528 IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: Intermountain Power
WORK ORDER: ______ *REV:* ______
TAG(S): ______

Given Information:

Fluid:	AIR		% H_2O (by volume):		
Standard Temperature (T_{std}):	68	(deg. F)		0.00	(%, by volume)
Standard Barometric Pressure (P_{std}):	29.921	(in. Hg)			
Air Temperature (T):	680	**(deg. F)**	**Maximum Flow:**		
Stack/Duct Pressure (P_g):	0.00	(in. w.c.)		387,000	(lb/hr)
Actual Barometric Pressure (P_{bar}):	25.000	**(in. Hg)**		Wet	(Wet/Dry)
Air Density at Standard Conditions, DRY:	0.07513	(lbs/ft^3)			
Duct Shape:	RECT		Square Root Extraction? (Yes/No)		
Duct Height:	75.000	**(in.)**		Yes	
Duct Width:	120.000	**(in.)**			
			Output:	4-20 mADC	

Calculations:

Duct Area (A_s):	62.500	(ft^2)
Maximum Actual Velocity:	3,550	(AFPM)
Absolute Duct Pressure (P_s):	25.000	(in. Hg)
Dry Mole Fraction of Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.02907	(lbs/ft^3)

NOTE: Due to the large positive bias, the DP is completely offset at lower flows (hence no DP).

Gain:	0.85
% Bias:	14.31
K-Factor:	ON

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
		4.00	0	0	0	0	0
		4.00	22,184	8,585	8,585	38,700	38,700
		4.00	44,369	17,170	17,170	77,400	77,400
		4.00	66,553	25,755	25,755	116,100	116,100
40	0.0060	10.40	88,738	34,340	34,340	154,800	154,800
50	0.0383	12.00	110,924	42,926	42,926	193,500	193,500
60	0.0776	13.60	133,109	51,511	51,511	232,200	232,200
70	0.1241	15.20	155,293	60,096	60,096	270,900	270,900
80	0.1778	16.80	177,478	68,681	68,681	309,600	309,600
90	0.2386	18.40	199,662	77,266	77,266	348,300	348,300
100	0.3066	20.00	221,846	85,851	85,851	387,000	387,000

Transmitter:	CAMM	Power (voltage/type):	24VAC
Flow Element:	VOLU-probe/SS w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0-387,000 lbs/hr	Square Root:	ON
Temperature Range:	0 to 700deg.	Density Compensation:	ON
Pressure Comp. Range:	?		

Temperature Sensor: Single-Pt. Type "E" T/C Probe with panel-mounted 4-20mADC temperature transmitter.

Display Line #1:	0-387,000 lbs/hr	(FLOW)
Display Line #2:	0 to 700deg.	(TEMPERATURE)
Display Line #3:	?	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to .7528 IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

Field Service Visit Report

☐ *Additional paperwork attached*

Work Order Number 50600
Field Service Report # 1 **of** 1

Contact Information and Service Location

Name:	Jerry Finlinson	Office Phone:	435-864-6466
Firm:	IPSC		
Name:		Office Phone:	
Firm:			
Project:	PA Traverse WO# 50271	Location:	Delta, UT.

Instrument and Billing Information

Instruments:			
SNs:			
SNs:			

Billing Status: ☐ Warranty ☐ Contract ☐ Billable
☐ Start-up - paid ☐ Other

Service Activity

Problem Description or Service Request:

Traverse 8 mills to verify airflow.

Service Actions Taken:

Performed the required traversing. The traverse results accompany this report. The OFA ducts take off the top of the wind box at each corner of the boiler. Each OFA duct feeds multiple OFA nozzles. The OFA ducts have no turning vanes, thus the airflow profile is skewed toward the top of the OFA duct at the point where the traversing was performed and where the airflow measurement probes are installed.

Based upon the results of the traversing, the customer requested that K-factors be applied to all CAMM's.

Primary reason for service visit:
☒ Traversing Service ☐ Start-up ☐ Installation ☐ Repair ☐ Other

Was preventive maintenance service performed during this visit? ☐ Yes ☒ No

Service Repair Codes

Service Representative Signature: Dan Beistel **Date:** 5/19/04

Labor and Parts

Total Travel Time 12 hours
On Site Dates Start 5/11/04 End 5/13/04

Labor

Regular Days On-site	3	Overtime Hours	
Saturday/Sunday/Holidays		Double Time Hours	

Part Number	Qty	Description	Code
* *			
* *			
* *			
* *			

Call Resolution

Is this Service Call closed? ☒ Yes ☐ No

Describe follow up action required if the call is to remain open:

Note: Travel Expenses and Applicable State Sales Taxes will be added to the total amount billed.

Customer Signature Date

IP7_037072

AIR MONITOR CORPORATION

Field Service Visit Report Addendum

Work Order Number

Addendum Sheets for Field Service Report # -

Additional Information:

12/23/2010

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		663				
AVERAGE PRESSURE IN. W.C. (Pg)		3.86				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.78	25.78	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	28.68	20.57	
ACTUAL STACK VOLUME (Q acfm) =	107,532	77,148	-28.26
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	43,553	31,246	-28.26
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	43,553	31,246	-28.26
FLOW IN LBS/HR (wet) =	196333	140854	-28.26
FLOW IN LBS/HR (dry) =	196333	140854	-28.26

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030430
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037074

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.039	-22.00	587.4	0.005	0.000	3.88	3.89	0.000	0.000	3.88	3.89	0.000	-0.501	0.980	0.005	22.01	6.57
	2	0.038	-12.00	603.5	0.009	0.000	3.81	3.81	0.000	0.000	3.81	3.81	0.000	-0.501	0.980	0.009	12.01	9.37
	3	0.037	18.00	644.9	0.063	-0.033	3.82	3.80	0.002	0.000	3.82	3.80	-0.524	-30.953	1.136	0.072	35.35	22.69
	4	0.034	20.00	661	0.064	-0.033	3.91	3.86	0.003	0.000	3.91	3.85	-0.516	-31.647	1.150	0.074	36.87	22.73
	5	0.038	0.00	672.3	0.072	0.000	3.82	3.77	0 000	0.000	3.82	3.76	0.000	-0.501	0.980	0.071	0.50	27.96
	6	0.038	0.00	675.9	0.078	-0.057	3.78	3.74	0.000	0.000	3.78	3.73	-0.731	-2.573	0.984	0.077	2.57	29.18
	7	0.036	15.00	681.6	0.071	-0.050	3.91	3.89	0.000	0.000	3.91	3.89	-0.704	2.563	0.977	0.069	15.21	26.86
	8	0.038	14.00	682.9	0.073	-0.054	3.76	3.74	0.000	0.000	3.76	3.74	-0.740	-6.564	0.995	0.073	15.43	27.47
	9	0.039	14.00	685.1	0.124	-0.064	3.90	3.82	0.003	0.000	3.90	3.81	-0.516	-31.609	1.149	0.142	34.27	33.02
	10	0.038	15.00	684.9	0.106	-0.012	3.84	3.79	0.000	0.000	3.84	3.78	-0.113	-9.481	1.003	0.106	17.69	32.89
2	1	0.036	-13.00	662.1	0.034	-0.015	3.94	3.95	0.004	0.000	3.94	3.95	-0.441	-32.242	1.162	0.040	34.50	17.16
	2	0.039	0.00	666.6	0.041	-0.020	3.81	3.82	0.005	0.000	3.81	3.82	-0.488	-32.980	1.178	0.048	32.98	19.36
	3	0.038	0.00	670	0.031	-0.018	3.84	3.85	-0.006	0.000	3.84	3.85	-0.581	-22.097	1.034	0.032	22.10	17.45
	4	0.038	1.00	673.6	0.045	-0.017	3.82	3.82	-0.003	0.000	3.82	3.82	-0.378	-27.651	1.081	0.049	27.67	20.57
	5	0.037	5.00	675.7	0.055	-0.020	3.86	3.85	-0.005	0.000	3.86	3.85	-0.364	-26.385	1.065	0.059	26.82	22.77
	6	0.037	-2.00	677.9	0.064	-0.018	3.88	3.86	-0.005	0.000	3.88	3.86	-0.281	-19.329	1.025	0.066	19.43	25.49
	7	0.038	5.00	680.5	0.079	-0.023	4.00	3.97	-0.005	0.000	4.00	3.96	-0.291	-20.089	1.027	0.081	20.68	28.15
	8	0.035	13.00	682.9	0.096	-0.017	3.97	3.92	-0.001	0.000	3.97	3.91	-0.177	-12.974	1.013	0.097	18.29	31.31
	9	0.040	20.00	685.1	0.131	-0.021	3.93	3.84	-0.001	0.000	3.93	3.82	-0.160	-12.097	1.011	0.132	23.24	35.39
	10	0.037	25.00	686.8	0.157	-0.011	4.00	3.89	0.000	0.000	4.00	3.87	-0.070	-6.603	0.995	0.156	25.80	37.69
3	1	0.038	24.00	585.6	0.038	0.005	3.98	3.99	0.000	0.000	3.98	3.99	0.132	13.384	0.991	0.038	27.29	17.45
	2	0.038	0.00	601.5	0.037	-0.001	3.96	3.97	0.000	0.000	3.96	3.97	-0.027	-3.068	0.985	0.036	3.07	19.42
	3	0.041	6.00	614.9	0.036	0.001	3.88	3.90	0.000	0.000	3.88	3.90	0.028	2.365	0.977	0.035	6.45	19.11
	4	0.039	5.00	627.9	0.039	-0.001	3.84	3.85	0.000	0.000	3.84	3.85	-0.026	-2.942	0.985	0.038	5.80	20.12
	5	0.039	8.00	641.4	0.047	0.000	3.82	3.83	0.000	0.000	3.82	3.83	0.000	-0.501	0.980	0.046	8.02	22.06
	6	0.038	0.00	649.5	0.062	0.000	3.86	3.85	0.000	0.000	3.86	3.85	0.000	-0.501	0.980	0.061	0.50	25.68
	7	0.040	10.00	658.6	0.073	-0.002	4.04	4.02	0.000	0.000	4.04	4.02	-0.027	-3.101	0.985	0.072	10.47	27.58
	8	0.039	13.00	664.5	0.094	0.000	4.03	3.98	0.000	0.000	4.03	3.97	0.000	-0.501	0.980	0.092	13.01	31.01
	9	0.040	26.00	673.8	0.128	-0.002	3.85	3.77	0.000	0.000	3.85	3.76	-0.016	-2.015	0.983	0.126	26.07	33.56
	10	0.039	25.00	678.3	0.151	-0.003	3.96	3.85	0.000	0.000	3 96	3.83	-0.020	-2.412	0.983	0.148	25.11	36.83
4	1	0.036	-10.00	623.4	0.034	0.009	3.92	3.93	0.000	0.000	3.92	3.93	0.265	20.031	1.016	0.035	22.30	17.71
	2	0.037	15.00	635.7	0.030	0.013	3.85	3.87	0.000	0.000	3.85	3.87	0.433	19.954	1.016	0.030	24.78	16.41
	3	0.037	0.00	645.9	0.044	0.006	3.75	3.75	0.000	0.000	3.75	3.75	0.136	13.829	0.993	0.044	13.83	21.11
	4	0.038	7.00	671.1	0.066	0.009	3.99	3.97	0.000	0.000	3.99	3.97	0.136	13.829	0.993	0.066	15.47	25.95
	5	0.040	3.00	676.3	0.072	0.014	3.82	3.80	0.000	0.000	3.82	3.80	0.194	18.161	1.007	0.072	18.40	26.94
	6	0.041	6.00	680.1	0.085	0.016	3.81	3.77	0.000	0.000	3.81	3.76	0.188	17.808	1.005	0.085	18.76	29.24
	7	0.039	18.00	682.5	0.092	0.010	3.89	3.85	0.000	0.000	3.89	3.84	0.109	11.119	0.986	0.091	21.06	29.72
	8	0.038	18.00	685.1	0.115	0.012	4.12	4.05	0.000	0.000	4.12	4.04	0.104	10.668	0.985	0.113	20.83	33.30
	9	0.041	15.00	685.8	0.129	0.010	4.04	3.96	0.000	0.000	4.04	3.95	0.078	7.791	0.980	0.126	16.86	36.03
	10	0.039	20.00	687.1	0.130	0.006	3.96	3.87	0.000	0.000	3.96	3.85	0.046	4.349	0.977	0.127	20.45	35.38
5	1	0.038	4.00	688.2	0.147	-0.007	3.97	3.87	0.000	0.000	3.97	3.85	-0.048	-4.847	0.990	0.145	6.28	40.19
	2	0.036	5.00	593.7	0.032	0.015	3.98	4.00	-0.001	0.000	3.98	4.00	0.469	24.501	1.056	0.034	24.98	16.92
	3	0.038	0.00	630.5	0.048	0.015	3.85	3.85	0.000	0.000	3.85	3.85	0.313	19.377	1.013	0.049	19.38	21.48
	4	0.040	4.00	643.9	0.091	0.022	3.81	3.76	0.000	0.000	3.81	3.75	0.242	19.846	1.015	0.092	20.23	29.65
	5	0.041	-2.00	659.4	0.101	0.031	3.97	3.91	0.000	0.000	3.97	3.90	0.307	19.504	1.013	0.102	19.60	31.54
	6	0.040	5.00	667.2	0.121	0.034	4.04	3.96	0.000	0.000	4.04	3.95	0.281	19.941	1.016	0.123	20.53	34.47
	7	0.041	2.00	674.9	0.139	0.040	3.82	3.73	0.000	0.000	3 82	3.71	0.288	19.857	1.015	0.141	19.95	37.22
	8	0.038	5.00	678.6	0.142	0.043	3.83	3.73	0.000	0.000	3.83	3.71	0.303	19.592	1.014	0.144	20.20	37.59
	9	0.039	5.00	685.5	0.131	0.028	3.96	3.87	0.000	0.000	3.96	3.85	0.214	19.065	1.011	0.132	19.69	36.28
	10	0.040	7.00	688.2	0.127	0.014	3.75	3.67	0.000	0.000	3.75	3.66	0.110	11.277	0.987	0.125	13.25	36.53
6	1	0.039	5.00	688.9	0.148	0.001	3.85	3.75	0.000	0.000	3.85	3.73	0.007	0.178	0.979	0.145	5.00	40.21
	2	0.039	-5.00	650.4	0.073	0.011	3.90	3.87	0.000	0.000	3.90	3.86	0.151	15.094	0.996	0.073	15.88	27.04
	3	0.040	-5.00	661.9	0.114	0.026	4.05	3.97	0.000	0.000	4.05	3.96	0.228	19.543	1.013	0.116	20.15	33.43
	4	0.040	7.00	672.6	0.119	0.049	4.11	4.03	0.000	0.000	4.11	4.02	0.412	18.627	1.009	0.120	19.85	34.30
	5	0.039	10.00	678.9	0.171	0.055	4.02	3.88	0.000	0.000	4.02	3.86	0.322	19.154	1.011	0.173	21.52	40.84
	6	0.038	0.00	682.7	0.192	0.069	4.05	3.90	0.000	0.000	4.05	3.87	0.359	18.275	1.007	0.193	18.28	44.16
	7	0.040	-2.00	685	0.183	0.065	4.00	3.87	0.000	0.000	4.00	3.85	0.355	18.352	1.008	0.184	18.46	43.12
	8	0.040	3.00	686.9	0.162	0.063	4.15	4.03	0.000	0.000	4.15	4.01	0.389	18.089	1.006	0.163	18.33	40.60
	9	0.039	3.00	688.1	0.150	0.045	4.00	3.89	0.000	0.000	4.00	3.87	0.300	19.649	1.014	0.152	19.87	38.88
	10	0.039	1.00	690.3	0.128	0.007	3.99	3.90	0.000	0.000	3.99	3.88	0.055	5.283	0.977	0.125	5.38	37.36

Avg. Duct Static = 3.86

Yaw Avg. = 6.28	Average Temp.
Std. Dev. = 9.78	663

Pitch Avg. = 2.24	Result Angle Avg. = 18.48	Traverse Avg. Velo
Std. Dev. = 16.75	Std. Dev. = 10.09	28.68

IP7_037075

Probes Point Velocity
19.99
19.89
20.00
19.31
20.52
20.56
20.05
20.62
20.91
20.64
19.88
20.74
20.50
20.53
20.28
20.30
20.59
19.78
21.17
20.38
19.71
19.86
20.77
20.38
20.50
20.31
20.92
20.71
21.07
20.84
19.53
19.92
20.01
20.51
21.09
21.39
20.88
20.63
21.44
20.92
20.66
19.26
20.14
20.79
21.19
21.00
21.34
20.58
20.91
21.21
20.94
20.59
20.95
21.05
20.85
20.61
21.17
21.18
20.93
20.95

Probes
›city in ft/s
20.57

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		676				
AVERAGE PRESSURE IN. W.C. (Pg)		3.09				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.73	25.73	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	39.16	35.53	
ACTUAL STACK VOLUME (Q acfm) =	146,852	133,239	-9.27
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	58,675	53,235	-9.27
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	58,675	53,235	-9.27
FLOW IN LBS/HR (wet) =	264502	239979	-9.27
FLOW IN LBS/HR (dry) =	264502	239979	-9.27

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030019
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.103	-12.00	574.8	0.011	-0.002	3.03	3.07	-0.001	0.000	3.03	3.08	-0.182	-13.221	1.013	0.011	17.78	10.13
	2	0.101	5.00	598.5	0.008	0.000	2.96	3.00	0.000	0.000	2.96	3.01	0.000	-0.501	0.980	0.008	5.02	8.99
	3	0.102	8.00	625.5	0.049	0.000	2.92	2.92	0.000	0.000	2.92	2.92	0.000	-0.501	0.980	0.048	8.02	22.39
	4	0.107	5.00	643.2	0.095	-0.053	3.03	2.98	-0.005	0.000	3.03	2.97	-0.558	-26.478	1.067	0.101	26.91	29.53
	5	0.106	2.00	656.7	0.149	-0.085	3.20	3.10	-0.006	-0.001	3.20	3.08	-0.570	-24.186	1.046	0.156	24.26	37.66
	6	0.102	0.00	672	0.131	-0.083	3.04	2.95	0.000	0.000	3.04	2.93	-0.634	-8.927	1.002	0 131	8.93	37.72
	7	0.103	0.00	678.4	0.163	-0.082	3.11	3.00	0.004	0.001	3.11	2.98	-0.503	-32.439	1.166	0.190	32.44	38.89
	8	0.102	10.00	683.9	0.146	-0.072	3.07	2.97	0.005	0.001	3.07	2.95	-0.493	-32.841	1.175	0.172	34.17	36.30
	9	0.100	18.00	691.6	0.214	-0.074	3.26	3.09	-0.006	-0.001	3.26	3.06	-0.346	-24.767	1.050	0.225	30.28	43.51
	10	0.106	5.00	690.9	0.048	0.000	2.98	2.98	0.000	0.000	2.98	2.98	0.000	-0.501	0.980	0.047	5.02	22.95
2	1	0.110	-5.00	660.9	0.020	-0.012	3.07	3.09	-0.004	0.000	3.07	3.09	-0.600	-17.620	1.022	0.020	18.29	14.23
	2	0.115	-8.00	670.8	0.034	0.000	3.01	3.03	0.000	0.000	3.01	3.03	0.000	-0.501	0.980	0.033	8.02	19.03
	3	0.114	-2.00	678.8	0.087	-0.033	3.02	2.98	-0.003	0.000	3.02	2.97	-0.379	-27.786	1.083	0.094	27.85	28.68
	4	0.111	8.00	685.5	0.104	-0.028	3.27	3.21	-0.004	0.000	3.27	3.20	-0.269	-18.447	1.023	0.106	20.05	32.48
	5	0.113	-6.00	690.4	0.102	-0.030	3.03	2.98	-0.005	-0.001	3.03	2.97	-0.294	-20.324	1.028	0.105	21.16	32.08
	6	0.113	0.00	692.7	0.122	-0.036	3.03	2.95	-0.005	-0.001	3.03	2.94	-0.295	-20.401	1.028	0.125	20.40	35.30
	7	0.116	7.00	696.5	0.176	-0.045	3.25	3.12	-0.004	-0.001	3.25	3.10	-0.256	-17.510	1.022	0.180	18.82	42.74
	8	0.114	5.00	698	0.172	-0.041	3.40	3.27	-0.003	-0.001	3.40	3.25	-0.238	-16.394	1.020	0.175	17.12	42.64
	9	0.109	10.00	698.8	0.183	-0.023	3.19	3.05	0.000	0.000	3.19	3.03	-0.126	-10.212	1.006	0.184	14.26	44.33
	10	0.112	25.00	700.4	0.233	-0.020	3.33	3.14	0.000	0.000	3.33	3.11	-0.086	-7.726	0.998	0.233	26.09	46.20
3	1	0.113	2.00	630.2	0.002	-0.001	2.99	3.04	0.005	0.000	2.99	3.05	-0.500	-32.584	1.169	0.002	32.64	4.21
	2	0.115	-5.00	647	0.058	-0.011	3.00	2.99	-0.001	0.000	3.00	2.99	-0.190	-13.634	1.014	0.059	14.51	24.47
	3	0.111	12.00	664.7	0.073	-0.005	2.84	2.81	0.000	0.000	2.84	2.80	-0.068	-6.486	0.994	0.073	13.62	27.51
	4	0.112	-4.00	672.9	0.096	-0.007	2.91	2.86	0.000	0.000	2.91	2 85	-0.073	-6.812	0.995	0.096	7.90	32.29
	5	0.112	5.00	678.9	0.090	-0.002	2.92	2.87	0.000	0.000	2.92	2.86	-0.022	-2.630	0.984	0.089	5.65	31.31
	6	0.112	5.00	684.7	0.126	-0.002	3.15	3.07	0.000	0.000	3.15	3.06	-0.016	-2.039	0.983	0.124	5.40	37.12
	7	0.115	8.00	694.3	0.197	0.004	3.15	2.99	0.000	0.000	3.15	2.96	0.020	1.576	0.977	0.193	8.15	46.22
	8	0.117	10.00	696.9	0.243	0.000	3.19	2.99	0.000	0.000	3.19	2.96	0.000	-0.501	0.980	0.238	10.01	51.19
	9	0.112	10.00	697.4	0.274	0.014	3.25	3.01	0.000	0.000	3.25	2.97	0.051	4.889	0.977	0.268	11.12	54.10
	10	0.112	28.00	614.9	0.042	0.005	3.18	3.18	0.000	0.000	3.18	3.18	0.119	12.168	0.989	0.042	30.33	18.05
4	1	0.116	10.00	642.3	0.065	0.003	3.20	3.18	0.000	0.000	3.20	3.18	0.046	4.349	0.977	0.064	10.90	25.73
	2	0.115	10.00	659.9	0.133	0.013	3.31	3.22	0.000	0.000	3.31	3.20	0.098	9.973	0.984	0.131	14.09	36.77
	3	0.117	8.00	674.4	0.148	0.018	3.23	3.12	0.000	0.000	3.23	3.10	0.122	12.423	0.989	0.146	14.74	39.03
	4	0.114	6.00	682.3	0.122	0.029	3.04	2.96	0.000	0.000	3.04	2.95	0.238	19.771	1.015	0.124	20.63	34.86
	5	0.117	-3.00	688.4	0.155	0.024	2.58	2.47	0.000	0.000	2.58	2.45	0.155	15.439	0.997	0.155	15.72	40.20
	6	0.112	4.00	691.6	0.190	0.025	3.32	3.17	0.000	0.000	3.32	3.14	0.132	13.384	0.991	0.188	13.96	44.76
	7	0.115	7.00	694.3	0.229	0.028	3.37	3.18	0.000	0.000	3.37	3.15	0.122	12.487	0.989	0.227	14.29	49.07
	8	0.119	7.00	696.9	0.259	0.028	3.39	3.17	0.000	0.000	3.39	3.13	0.108	11.058	0.986	0.255	13.06	52.44
	9	0.118	2.00	698.3	0.275	0.000	3.49	3.25	0.000	0.000	3.49	3.21	0.000	-0.501	0.980	0.269	2.06	55.28
	10	0.118	23.00	641.3	0.138	0.012	3.38	3.28	0.000	0.000	3.38	3.26	0.087	8.817	0.982	0.135	24.55	34.79
5	1	0.114	5.00	669	0.166	0.024	3.18	3.05	0.000	0.000	3.18	3.03	0.145	14.568	0.995	0.165	15.38	41.23
	2	0.114	2.00	683.1	0.226	0.050	3.31	3.12	0.000	0.000	3.31	3.09	0.221	19.335	1.012	0.229	19.43	47.76
	3	0.116	0.00	689.4	0.242	0.054	3.49	3.28	0.000	0.000	3.49	3.24	0.223	19.397	1.013	0.245	19.40	49.57
	4	0.116	-2.00	692.1	0.220	0.074	3.39	3.21	0.000	0.000	3.39	3.18	0.336	18.781	1.010	0.222	18.88	47.39
	5	0.114	5.00	694.5	0.256	0.067	3.30	3.07	0.000	0.000	3.30	3.03	0.262	20.028	1.016	0.260	20.62	50.80
	6	0.119	3.00	696.1	0.263	0.069	3.30	3.07	0.000	0.000	3.30	3.03	0.262	20.029	1.016	0.267	20.24	51.65
	7	0.116	10.00	697.2	0.246	0.060	3.36	3.15	0.000	0.000	3.36	3.11	0 244	19.880	1 015	0.250	22.16	49.31
	8	0.118	15.00	697.8	0.223	0.032	3.46	3.28	0.000	0.000	3.46	3.25	0.143	14.473	0.994	0 222	20.73	46.92
	9	0.114	10.00	698.1	0.244	0.012	3.44	3.23	0.000	0.000	3.44	3.19	0.049	4.680	0.977	0.238	11.03	51.07
	10	0.118	8.00	648.2	0.242	0.022	3.59	3.38	0.000	0.000	3.59	3.34	0.091	9.243	0.983	0.238	12.20	49.67
6	1	0.121	-3.00	668.6	0.281	0.038	3.55	3.30	0.000	0.000	3.55	3.26	0.135	13.725	0.992	0.279	14.04	53.88
	2	0.115	-5.00	680.4	0.243	0.063	3.64	3.43	0.000	0.000	3.64	3.39	0.259	20.022	1.016	0.247	20.61	49.17
	3	0.118	-3.00	688.4	0.262	0.071	3.75	3.52	0.000	0.000	3.75	3.48	0.271	20.016	1.016	0.266	20.23	51.35
	4	0.124	-5.00	693	0.238	0.121	3.59	3.39	0.001	0.000	3.59	3.36	0.508	34.104	1.288	0.307	34.42	48.55
	5	0.123	0.00	695.3	0.287	0.109	3.54	3.29	0.000	0.000	3.54	3.25	0.380	18.063	1.006	0.289	18.06	54.37
	6	0.119	3.00	696.6	0.261	0.091	3.53	3.30	0.000	0.000	3.53	3.26	0.349	18.489	1.008	0.263	18.72	51.73
	7	0.121	0.00	697.4	0.218	0.062	3.55	3.37	0.000	0.000	3.55	3.34	0.284	19.902	1.015	0.221	19.90	47.12
	8	0.118	2.00	697.9	0.233	0.017	3.65	3.45	0.000	0.000	3.65	3.42	0.073	7.292	0.980	0.228	7.56	50.44
	9	0.118	5.00	679.5	0.262	0.001	3.46	3.23	0.000	0.000	3.46	3.19	0.004	-0.119	0.979	0.257	5.00	53.33
	10																	

Avg Duct Static = 3.09

	Average Temp.
Yaw Avg. = 4.58	
Std. Dev. = 7.63	676

		Traverse Avg. Velo
Pitch Avg. = 0.88	Result Angle Avg. = 17.07	
Std. Dev = 16.76	Std. Dev. = 7.96	39.16

IP7_037079

Probes Point Velocity
32.33
32.38
32.96
34.03
34.07
33.66
33.92
33.83
33.61
34.59
34.77
35.71
35.69
35.31
35.71
35.75
36.27
35.97
35.20
35.70
34.76
35.34
35.00
35.29
35.38
35.46
36.09
36.44
35.66
34.36
35.41
35.53
36.08
35.74
36.33
35.56
36.08
36.74
36.61
35.69
35.53
35.75
36.15
36.20
35.93
36.74
36.28
36.60
35.98
35.80
36.59
35.85
36.43
37.43
37.32
36.73
37.05
36.59
36.31

Probes
ocity in ft/s
35.53

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)	68					
STD. BAROMETRIC PRESSURE " Hg (Pstd)	29.92					
DUCT SIZE (D) Traverse	75.000	120.000		75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)	662					
AVERAGE PRESSURE IN. W.C. (Pg)	2.08					
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)	25.50					
% O2 (20.95)	20.95					
% N2 (78.09)	78.09					
% CO2 (0.03)	0.03					
% CO (0.0)	0.00					
%A (0.93)	0.93					
% H2O (0.0)	0.00					

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.65	25.65	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	45.75	43.65	
ACTUAL STACK VOLUME (Q acfm) =	171,580	163,672	-4.61
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	69,223	66,033	-4.61
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	69,223	66,033	-4.61
FLOW IN LBS/HR (wet) =	312051	297671	-4.61
FLOW IN LBS/HR (dry) =	312051	297671	-4.61

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030312
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037082

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.164	-10.00	607.4	0.019	0.005	2.07	2.06	0.000	0.000	2.07	2.06	0.263	20.030	1.016	0.019	22.30	13.17
	2	0.164	-8.00	617.5	0.065	-0.012	2.06	2.01	-0.001	0.000	2.06	2.00	-0.185	-13.368	1.014	0.066	15.54	25.46
	3	0.167	4.00	635.7	0.073	-0.046	1.87	1.81	0.000	0.000	1.87	1.80	-0.630	-9.833	1.005	0.073	10.61	27.64
	4	0.165	14.00	647.1	0.097	-0.058	1.90	1.82	-0.004	0.000	1.90	1.81	-0.598	-18.124	1.023	0.099	22.76	30.32
	5	0.176	5.00	657.3	0.121	0.000	2.03	1.92	0.000	0.000	2.03	1.90	0.000	-0.501	0.980	0.119	5.02	35.96
	6	0.175	-2.00	664.5	0.161	-0.081	2.05	1.90	0.004	0.001	2.05	1.87	-0.503	-32.437	1.166	0.188	32.49	38.45
	7	0.167	6.00	669.3	0.202	-0.094	2.06	1.87	0.005	0.001	2.06	1.84	-0.465	-33.025	1.179	0.238	33.50	42.90
	8	0.165	10.00	672.6	0.234	-0.086	2.13	1.90	-0.004	-0.001	2.13	1.86	-0.368	-26.736	1.069	0.250	28.42	46.45
	9	0.170	18.00	676.2	0.280	-0.098	2.32	2.05	-0.005	-0.002	2.32	2.00	-0.350	-25.148	1.053	0.295	30.58	49.43
	10	0.171	11.00	678.2	0.271	-0.017	2.33	2.07	0.000	0.000	2.33	2.03	-0.063	-6.050	0.993	0.269	12.54	53.59
2	1	0.173	8.00	613.2	0.029	-0.003	2.11	2.10	0.000	0.000	2.11	2.10	-0.103	-8.880	1.002	0.029	11.93	17.13
	2	0.172	-15.00	640.5	0.030	-0.021	2.24	2.22	0.000	0.000	2.24	2.22	-0.700	2.657	0.977	0.029	15.23	17.18
	3	0.165	3.00	649.9	0.057	-0.020	2.26	2.22	-0.005	0.000	2.26	2.21	-0.351	-25.228	1.054	0.060	25.39	23.13
	4	0.167	7.00	660.2	0.089	-0.017	2.43	2.35	-0.001	0.000	2.43	2.34	-0.191	-13.706	1.014	0.090	15.36	30.40
	5	0.173	0.00	665.1	0.083	-0.011	2.27	2.20	0.000	0.000	2.27	2.19	-0.133	-10.599	1.007	0.084	10.60	29.88
	6	0.173	-3.00	670	0.149	-0.022	2.27	2.13	0.000	0.000	2.27	2.11	-0.148	-11.426	1.009	0.150	11.81	40.01
	7	0.175	-9.00	675.6	0.211	-0.043	2.23	2.03	-0.002	0.000	2.23	2.00	-0.204	-14.392	1.016	0.214	16.92	46.81
	8	0.177	3.00	678.6	0.242	-0.033	2.43	2.20	0.000	0.000	2.43	2.16	-0.136	-10.812	1.007	0.244	11.22	51.24
	9	0.172	10.00	680.7	0.293	-0.025	2.60	2.32	0.000	0.000	2.60	2.27	-0.085	-7.690	0.998	0.292	12.59	55.89
	10	0.172	23.00	683.7	0.377	-0.014	2.50	2.13	0.000	0.000	2.50	2.07	-0.037	-3.961	0.987	0.372	23.32	59.42
3	1	0.178	3.00	603.6	0.029	-0.005	2.24	2.23	-0.001	0.000	2.24	2.23	-0.172	-12.730	1.012	0.029	13.07	17.07
	2	0.178	5.00	622.9	0.041	-0.006	2.11	2.08	0.000	0.000	2.11	2.07	-0.146	-11.356	1.009	0.041	12.39	20.50
	3	0.178	2.00	654.9	0.099	-0.003	2.38	2.29	0.000	0.000	2.38	2.27	-0.030	-3.361	0.986	0.098	3.91	32.63
	4	0.173	5.00	670.5	0.144	0.003	2.24	2.11	0.000	0.000	2.24	2.09	0.021	1.631	0.977	0.141	5.26	39.39
	5	0.178	0.00	674.5	0.130	0.014	2.23	2.12	0.000	0.000	2.23	2.10	0.108	11.015	0.986	0.128	11.02	37.12
	6	0.175	-10.00	677.6	0.182	-0.004	2.35	2.18	0.000	0.000	2.35	2.15	-0.022	-2.607	0.984	0.179	10.33	44.03
	7	0.174	-2.00	680.3	0.226	-0.004	2.54	2.32	0.000	0.000	2.54	2.28	-0.018	-2.210	0.983	0.222	2.98	49.83
	8	0.174	4.00	682.2	0.268	0.006	2.47	2.21	0.000	0.000	2.47	2.17	0.022	1.795	0.977	0.262	4.38	54.08
	9	0.173	12.00	684	0.320	0.005	2.42	2.10	0.000	0.000	2.42	2.04	0.016	1.088	0.978	0.313	12.05	58.03
	10	0.173	24.00	685.2	0.396	0.004	2.38	1.99	0.000	0.000	2.38	1.92	0.010	0.518	0.978	0.387	24.01	60.36
4	1	0.173	12.00	587.1	0.058	-0.002	2.07	2.03	0.000	0.000	2.07	2.02	-0.034	-3.730	0.987	0.057	12.56	23.70
	2	0.174	7.00	606.7	0.080	0.004	2.15	2.08	0.000	0.000	2.15	2.07	0.050	4.769	0.977	0.078	8.46	28.33
	3	0.169	10.00	624	0.162	0.012	2.49	2.34	0.000	0.000	2.49	2.31	0.074	7.414	0.980	0.159	12.43	40.16
	4	0.174	9.00	651.6	0.219	0.019	2.20	1.99	0.000	0.000	2.20	1.95	0.087	8.796	0.982	0.215	12.56	47.33
	5	0.171	5.00	659.8	0.183	0.025	2.18	2.01	0.000	0.000	2.18	1.98	0.137	13.852	0.993	0.182	14.71	43.27
	6	0.173	0.00	666.5	0.237	0.023	2.19	1.96	0.000	0.000	2.19	1.92	0.097	9.899	0.984	0.233	9.90	50.08
	7	0.173	3.00	672.6	0.281	0.028	2.28	2.00	0.000	0.000	2.28	1.95	0.100	10.174	0.984	0.277	10.60	54.57
	8	0.169	12.00	679.2	0.322	0.035	2.55	2.23	0.000	0.000	2.55	2.17	0.109	11.119	0.986	0.318	16.30	57.25
	9	0.178	11.00	682.5	0.344	0.023	2.35	2.02	0.000	0.000	2.35	1.96	0.067	6.622	0.979	0.337	12.82	59.99
	10	0.169	10.00	684.3	0.377	0.003	2.40	2.03	0.000	0.000	2.40	1.97	0.008	0.300	0.979	0.369	10.00	63.47
5	1	0.168	0.00	628.8	0.189	0.011	2.45	2.28	0.000	0.000	2.45	2.25	0.058	5.669	0.978	0.185	5.67	44.26
	2	0.175	1.00	644.6	0.209	0.043	2.33	2.13	0.000	0.000	2.33	2.10	0.206	18.726	1.009	0.211	18.75	45.33
	3	0.176	5.00	666.6	0.363	0.049	2.37	2.02	0.000	0.000	2.37	1.96	0.135	13.702	0.992	0.360	14.57	61.16
	4	0.176	0.00	673.2	0.331	0.049	2.41	2.09	0.000	0.000	2.41	2.03	0.148	14.868	0.995	0.329	14.87	58.57
	5	0.174	3.00	676.7	0.318	0.068	2.55	2.24	0.000	0.000	2.55	2.19	0.214	19.068	1.011	0.321	19.29	56.58
	6	0.174	0.00	682.2	0.376	0.075	2.49	2.12	0.000	0.000	2.49	2.06	0.199	18.424	1.008	0.379	18.42	61.91
	7	0.176	2.00	684.8	0.372	0.076	2.40	2.04	0.000	0.000	2.40	1.98	0.204	18.659	1.009	0.375	18.76	61.57
	8	0.173	10.00	687.3	0.365	0.070	2.42	2.07	0.000	0.000	2.42	2.01	0.192	18.013	1.006	0.367	20.52	60.30
	9	0.177	12.00	688.8	0.318	0.026	2.47	2.17	0.000	0.000	2.47	2.12	0.082	8.253	0.981	0.312	14.53	57.47
	10	0.173	12.00	689.8	0.364	0.006	2.68	2.33	0.000	0.000	2.68	2.27	0.016	1.177	0.978	0.356	12.06	62.02
6	1	0.175	-2.00	626	0.323	0.012	2.50	2.21	0.000	0.000	2.50	2.16	0.037	3.371	0.977	0.315	3.92	57.91
	2	0.172	-5.00	649.2	0.263	0.019	2.59	2.35	0.000	0.000	2.59	2.31	0.072	7.213	0.979	0.258	8.77	52.37
	3	0.174	3.00	659.8	0.339	0.046	2.59	2.27	0.000	0.000	2.59	2.21	0.136	13.767	0.992	0.336	14.08	59.03
	4	0.171	5.00	669.3	0.320	0.048	2.39	2.10	0.000	0.000	2.39	2.05	0.150	15.036	0.996	0.319	15.83	57.24
	5	0.174	3.00	675.5	0.350	0.084	2.45	2.12	0.000	0.000	2.45	2.06	0.240	19.815	1.015	0.355	20.03	59.18
	6	0.179	0.00	680.4	0.372	0.094	2.46	2.11	0.000	0.000	2.46	2.05	0.253	19.983	1.016	0.378	19.98	61.19
	7	0.176	4.00	684.1	0.332	0.083	2.43	2.13	0.000	0.000	2.43	2.08	0.250	19.957	1.016	0.337	20.34	57.76
	8	0.174	7.00	686.7	0.284	0.064	2.42	2.17	0.000	0.000	2.42	2.13	0.225	19.465	1.013	0.288	20.64	53.30
	9	0.173	3.00	688.1	0.293	0.008	2.33	2.07	0.000	0.000	2.33	2.03	0.027	2.315	0.977	0.286	3.79	56.73
	10	0.177	2.00	688.9	0.356	-0.007	2.43	2.11										

Avg. Duct Static = 2.08

	Average Temp.
Yaw Avg. = 4.37	
Std. Dev. = 7.33	662

		Traverse Avg. Velo
Pitch Avg. = 1.04	Result Angle Avg. = 14.79	
Std. Dev. = 14.07	Std. Dev. = 7.05	45.75

INTERMOUNTAIN OFA (14' probe)1

IP7_037083

Probes Point Velocity
41.50
41.69
42.44
42.40
43.99
44.01
43.08
42.89
43.59
43.76
42.73
43.14
42.43
42.88
43.75
43.85
44.22
44.52
43.92
43.99
43.14
43.54
44.17
43.86
44.57
44.25
44.16
44.21
44.12
44.15
42.21
42.73
42.43
43.62
43.40
43.79
43.91
43.51
44.73
43.62
42.41
43.60
44.17
44.29
44.10
44.21
44.52
44.19
44.72
44.22
43.23
43.30
43.77
43.58
44.08
44.81
44.50
44.30
44.20

Probes
ocity in ft/s
43.65

IP7_037085

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		660				
AVERAGE PRESSURE IN. W.C. (Pg)		3.32				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.74	25.74	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	27.51	22.55	
ACTUAL STACK VOLUME (Q acfm) =	103,156	84,555	-18.03
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	41,845	34,300	-18.03
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	41,845	34,300	-18.03
FLOW IN LBS/HR (wet) =	188634	154621	-18.03
FLOW IN LBS/HR (dry) =	188634	154621	-18.03

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030478
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037086

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.048	-8.00	615.9	0.032	0.001	3.26	3.28	0.000	0.000	3.26	3.28	0.031	2.736	0.977	0.031	8.45	17.96
	2	0.051	-15.00	627.4	0.025	-0.001	3.33	3.35	0.000	0.000	3.33	3.35	-0.040	-4.207	0.988	0.025	15.57	15.63
	3	0.049	3.00	636.5	0.064	0.005	3.48	3.47	0.000	0.000	3.48	3.47	0.078	7.857	0.980	0.063	8.41	25.68
	4	0.046	0.00	645.4	0.030	-0.011	3.43	3.46	-0.004	0.000	3.43	3.47	-0.367	-26.659	1.069	0.032	26.66	16.65
	5	0.048	-2.00	653.6	0.059	-0.025	3.24	3.23	0.002	0.000	3.24	3.23	-0.424	-31 262	1.142	0.067	31.32	23.17
	6	0.050	-3.00	660.5	0.076	-0.031	3.32	3.30	0.000	0.000	3.32	3.30	-0.408	-30.149	1.121	0.085	30.28	26.41
	7	0.052	-2.00	666.4	0.100	-0.044	3.30	3.25	0.004	0.000	3.30	3.24	-0.440	-32.186	1.161	0.116	32.24	30.29
	8	0.046	0.00	672.9	0.092	-0.037	3.23	3.19	0.000	0.000	3.23	3.18	-0.402	-29.706	1.113	0.102	29.71	29.29
	9	0.050	5.00	681.1	0.112	-0.021	3.45	3.39	-0.001	0.000	3.45	3.38	-0.188	-13.520	1.014	0.114	14.40	34.51
	10	0.047	0.00	682.8	0.029	0.000	3.39	3.41	0.000	0.000	3.39	3.41	0.000	-0.501	0.980	0.028	0.50	17.84
2	1	0.048	15.00	623.3	0.030	0.007	3.19	3.22	0.000	0.000	3.19	3.23	0.233	19.677	1.014	0.030	24.56	16.35
	2	0.045	0.00	632.4	0.024	0.005	3.21	3.24	0.000	0.000	3.21	3.25	0.208	18.841	1.010	0.024	18.84	15.25
	3	0.048	0.00	638.3	0.027	0.000	3.21	3.24	0.000	0.000	3.21	3.25	0.000	-0.501	0.980	0.026	0.50	16.88
	4	0.048	-11.00	647	0.029	-0.008	3.12	3.15	-0.004	0.000	3.12	3.16	-0.276	-18.928	1.024	0.030	21.79	16.67
	5	0.046	-4.00	656.8	0.045	-0.009	3.21	3.22	-0.002	0.000	3.21	3.22	-0.200	-14.187	1.015	0.046	14.73	21.63
	6	0.047	0.00	662.7	0.056	-0.013	3.24	3.24	-0.003	0.000	3.24	3.24	-0.232	-16.014	1.019	0.057	16.01	24.09
	7	0.047	-5.00	669	0.071	-0.013	3.43	3.42	-0.001	0.000	3.43	3.42	-0.183	-13.288	1.013	0.072	14.18	27.35
	8	0.047	-5.00	675.6	0.086	-0.015	3.38	3.35	-0.001	0.000	3.38	3.34	-0.174	-12.834	1.012	0.087	13.76	30.23
	9	0.047	14.00	682.2	0.110	-0.013	3.30	3.24	0.000	0.000	3.30	3.23	-0.118	-9.777	1.004	0.110	17.02	33.63
	10	0.044	10.00	685.5	0.097	0.078	3.23	3.18	-0.006	-0.001	3.23	3.17	0.804	-23.745	1.043	0.101	25.65	30.39
3	1	0.047	20.00	613.7	0.038	0.004	3.31	3.33	0 000	0.000	3.31	3.33	0.105	10 763	0.986	0.037	22.61	18.33
	2	0.048	21.00	636.7	0.036	0.002	3.28	3.30	0.000	0.000	3.28	3.30	0.056	5.379	0.978	0.035	21.65	18.08
	3	0.046	3.00	645.3	0.028	-0.001	3.38	3.41	0.000	0.000	3.38	3.42	-0.036	-3.838	0.987	0.028	4.87	17.24
	4	0.041	0.00	652.8	0.035	0.001	3.47	3.49	0.000	0.000	3.47	3.49	0.029	2.450	0.977	0.034	2.45	19.29
	5	0.045	-3.00	660	0.035	-0.004	3.34	3.36	0.000	0.000	3.34	3.36	-0.114	-9.545	1.004	0.035	10.00	19.34
	6	0.049	-3.00	666	0.056	-0.006	3.28	3.28	0.000	0.000	3.28	3.28	-0.107	-9.111	1.002	0.056	9.59	24.54
	7	0.047	10.00	673.3	0.063	-0.001	3.28	3.27	0.000	0.000	3.28	3.27	-0.016	-2.039	0.983	0.062	10.20	25.81
	8	0.048	20.00	678.6	0.081	-0.001	3.33	3.30	0.000	0.000	3.33	3.29	-0.012	-1.704	0.982	0.080	20.07	27.98
	9	0.046	20.00	683.4	0.101	-0.003	3.31	3.26	0.000	0.000	3.31	3.25	-0.030	-3.308	0.985	0.100	20.26	31.33
	10	0.048	20.00	678.9	0.116	0.013	3.49	3.43	0.000	0.000	3.49	3.42	0.112	11.465	0.987	0.114	22.94	32.92
4	1	0.046	2.00	627.3	0.073	-0.002	3.36	3.34	0.000	0.000	3.36	3.34	-0.027	-3.101	0.985	0.072	3.69	27.62
	2	0.046	-3.00	638.3	0.054	-0.003	3.52	3.52	0.000	0.000	3.52	3.52	-0.056	-5.489	0.991	0.054	6.25	23.86
	3	0.047	-6.00	645.7	0.046	-0.003	3.33	3.34	0.000	0.000	3.33	3.34	-0.065	-6.239	0.994	0.046	8.65	22.00
	4	0.045	-2.00	653.2	0.054	0.000	3.30	3.30	0.000	0.000	3.30	3.30	0.000	-0.501	0.980	0.053	2.06	24.01
	5	0.043	-2.00	662.7	0.054	0.001	3.30	3.30	0.000	0.000	3.30	3.30	0.019	1.389	0.978	0.053	2.43	24.08
	6	0.047	-1.00	670.8	0.069	0.006	3.22	3.21	0.000	0.000	3.22	3.21	0.087	8.817	0.982	0.068	8.87	27.08
	7	0.043	1.00	675.6	0.076	0.003	3.27	3.25	0.000	0.000	3.27	3.25	0.039	3.622	0.977	0.074	3.76	28.68
	8	0.044	2.00	679.8	0.090	0.004	3.33	3.29	0.000	0.000	3.33	3.28	0.044	4.162	0.977	0.088	4.62	31.24
	9	0.047	5.00	683.9	0.109	0.003	3.37	3.32	0.000	0.000	3.37	3.31	0.028	2.338	0.977	0.106	5.52	34.39
	10	0.047	5.00	683.9	0.103	0.000	3.25	3.20	0.000	0.000	3.25	3.19	0.000	-0.501	0.980	0.101	5.02	33.51
5	1	0.042	-5.00	628.8	0.102	-0.005	3.43	3.38	0.000	0.000	3.43	3.37	-0.049	-4.962	0.990	0.101	7.04	32.57
	2	0.046	-2.00	642.8	0.085	0.000	3.52	3.49	0.000	0.000	3.52	3.48	0.000	-0.501	0.980	0.083	2.06	29.97
	3	0.046	-2.00	652	0.082	0.001	3.48	3.45	0.000	0.000	3.48	3.44	0.012	0.733	0.978	0.080	2.13	29.54
	4	0.042	-7.00	661.6	0.100	0.003	3.41	3.36	0.000	0.000	3.41	3.35	0.030	2.602	0.977	0.098	7.47	32.49
	5	0.042	0.00	668.8	0.123	0.008	3.37	3.30	0.000	0.000	3.37	3.29	0.065	6.422	0.978	0.120	6.42	36.26
	6	0.047	-6.00	673.8	0.107	0.011	3.34	3.29	0.000	0.000	3.34	3.28	0.103	10.506	0.985	0.105	12.08	33.47
	7	0.045	-3.00	678	0.116	0.009	3.28	3.21	0.000	0.000	3.28	3.20	0.078	7.798	0.980	0.114	8.35	35.24
	8	0.048	2.00	681.9	0.108	0.010	3.41	3.36	0.000	0.000	3.41	3.35	0.093	9.424	0.983	0.106	9.63	33.98
	9	0.047	2.00	685.2	0.118	0.009	3.38	3.31	0.000	0.000	3.38	3.30	0.076	7.654	0.980	0.116	7.91	35.69
	10	0.046	5.00	683.5	0.024	0.000	3.36	3.39	0.000	0.000	3.36	3.40	0.000	-0.501	0.980	0.024	5.02	16.17
6	1	0.046	-2.00	594.6	0.119	0.001	3.48	3.42	0.000	0.000	3.48	3.41	0.008	0.345	0.979	0.116	2.03	34.67
	2	0.046	5.00	624.5	0.117	0.001	3.25	3.18	0.000	0.000	3.25	3.17	0.009	0.360	0.979	0.114	5.01	34.76
	3	0.045	5.00	643.7	0.133	0.003	3.29	3.21	0.000	0.000	3.29	3.20	0.023	1.812	0.977	0.130	5.32	37.34
	4	0.043	0.00	657.9	0.151	0.008	3.40	3.30	0.000	0.000	3.40	3.28	0.053	5.096	0.977	0.148	5.10	40.05
	5	0.049	0.00	667.5	0.152	0.011	3.51	3.40	0.000	0.000	3.51	3.38	0.072	7.227	0.979	0.149	7.23	40.23
	6	0.045	2.00	676.5	0.140	0.017	3.62	3.52	0.000	0.000	3.62	3.50	0.121	12.404	0.989	0.138	12.56	38.32
	7	0.045	2.00	682.8	0.136	0.017	3.40	3.32	0.000	0.000	3.40	3.31	0.125	12.754	0.990	0.135	12.91	37.85
	8	0.046	2.00	688	0.116	0.018	3.36	3.30	0.000	0.000	3.36	3.29	0.155	15.466	0.997	0.116	15.59	34.75
	9	0.046	0.00	690.5	0.084	0.011	3.44	3.40	0.000	0.000	3.44	3.39	0.131	13.324	0.991	0.083	13.32	29.81
	10	0.045	8.00	688.8	0.063	0.000	3.53	3.52	0.000	0.000	3.53	3.52	0.000	-0.501	0.980	0.062	8.02	26.10

Avg. Duct Static = 3.32

Yaw Avg. = 1.78	Average Temp.
Std. Dev. = 7.62	660

Pitch Avg. = -1.93	Result Angle Avg. = 11.92	Traverse Avg. Velo
Std. Dev. = 12.36	Std. Dev. = 8.53	27.51

INTERMOUNTAIN OFA (14' probe)1

IP7_037087

Probes Point Velocity
22.50
23.31
22.94
22.32
22.89
23.43
23.96
22.60
23.64
22.94
22.58
21.95
22.73
22.83
22.44
22.74
22.80
22.87
22.94
22.23
22.24
22.71
22.32
21.14
22.22
23.26
22.85
23.14
22.71
23.14
22.14
22.25
22.57
22.16
21.75
22.83
21.88
22.17
22.96
22.96
21.17
22.29
22.39
21.49
21.56
22.85
22.41
23.18
22.97
22.70
21.80
22.12
22.07
21.71
23.27
22.38
22.45
22.75
22.77
22.50

Probes
city in ft/s
22.55

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		685				
AVERAGE PRESSURE IN. W.C. (Pg)		2.65				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.69	25.69	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	37.86	34.92	
ACTUAL STACK VOLUME (Q acfm) =	141,977	130,965	-7.76
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	56,212	51,851	-7.76
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	56,212	51,851	-7.76
FLOW IN LBS/HR (wet) =	253399	233740	-7.76
FLOW IN LBS/HR (dry) =	253399	233740	-7.76

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029746
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037090

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.100	-2.00	651.1	0.057	0.003	2.60	2.59	0.000	0.000	2.60	2.59	0.053	5.058	0.977	0.056	5.44	24.54
	2	0.108	-3.00	663.4	0.057	0.000	2.71	2.71	0.000	0.000	2.71	2.71	0.000	-0.501	0.980	0.056	3.04	24.78
	3	0.105	-2.00	669.5	0.050	0.000	2.49	2.49	0.000	0.000	2.49	2.49	0.000	-0.501	0.980	0.049	2.06	23.30
	4	0.104	-7.00	676.2	0.060	0.016	2.58	2.57	0.000	0.000	2.58	2.57	0.267	20.029	1.016	0.061	21.17	24.32
	5	0.110	-4.00	681.3	0.050	-0.021	2.42	2.42	0.002	0.000	2.42	2.42	-0.420	-31.017	1.137	0.057	31.25	21.59
	6	0.105	0.00	686.9	0.094	-0.049	2.53	2.48	0.002	0.000	2.53	2.47	-0.521	-31.183	1.141	0.107	31.18	29.74
	7	0.104	4.00	690.9	0.138	-0.069	2.62	2.54	0.005	0.001	2.62	2.53	-0.500	-32.584	1.169	0.161	32.80	35.90
	8	0.108	9.00	694.9	0.168	-0.070	2.82	2.70	0 001	0.000	2.82	2.68	-0.417	-30.788	1.133	0.190	31.95	39.42
	9	0.101	15.00	698	0.167	-0.034	2.55	2.43	-0.002	0.000	2.55	2.41	-0.204	-14.381	1.016	0.170	20.67	41.11
	10	0.107	10.00	698.4	0.069	0.000	2.38	2.36	0.000	0.000	2.38	2.36	0.000	-0.501	0.980	0.068	10.01	27.32
2	1	0.106	4.00	638.4	0.102	0.017	2.44	2.39	0.000	0.000	2.44	2.38	0.167	16.365	1.000	0.102	16.83	31.76
	2	0.106	-3.00	656.9	0.084	0.018	2.53	2.50	0.000	0.000	2.53	2.49	0.214	19.086	1.011	0.085	19.31	28.81
	3	0.107	7.00	667.1	0.067	0.009	2.39	2.37	0.000	0.000	2.39	2.37	0.134	13.641	0.992	0.066	15.30	26.17
	4	0.101	-5.00	674.3	0.059	-0.008	2.35	2.35	0.000	0.000	2.35	2.35	-0.136	-10.770	1.007	0.059	11.86	25.19
	5	0.104	0.00	680.2	0.051	-0.005	2.45	2.45	0.000	0.000	2.45	2.45	-0.098	-8.536	1.001	0.051	8.54	23.65
	6	0.105	0.00	685.8	0.071	-0.013	2.70	2.68	-0.001	0.000	2.70	2.68	-0.183	-13.288	1.013	0.072	13.29	27.69
	7	0.099	-5.00	690.5	0.114	-0.022	2.46	2.40	-0.001	0.000	2.46	2.39	-0.193	-13.810	1.015	0.116	14.67	34.98
	8	0.109	6.00	695.5	0.150	-0.029	2.52	2.42	-0.001	0.000	2.52	2.40	-0.193	-13.829	1.015	0.152	15.05	40.14
	9	0.107	4.00	699.2	0.186	-0.028	2.56	2.42	0.000	0.000	2.56	2.40	-0.151	-11.580	1.009	0.188	12.24	45.19
	10	0.102	15.00	700.7	0.144	-0.050	2.45	2.35	-0.005	-0.001	2.45	2.33	-0.347	-24.896	1.051	0.151	28.82	36.41
3	1	0.108	10.00	644.6	0.128	0.032	2.68	2.60	0.000	0.000	2.68	2.59	0.250	19.957	1.016	0.130	22.23	34.76
	2	0.109	10.00	659.4	0.113	-0.050	2.64	2.58	0.004	0.001	2.64	2.57	-0.442	-32.303	1.164	0.131	33.65	31.65
	3	0.107	5.00	668.1	0.079	-0.050	2.65	2.62	0.000	0.000	2.65	2.61	-0.633	-9.104	1.002	0.079	10.38	29.13
	4	0.106	0.00	676.1	0.062	0.013	2.73	2.72	0.000	0.000	2.73	2.72	0.210	18.899	1.010	0.063	18.90	25.01
	5	0.106	3.00	683	0.058	0.000	2.82	2.82	0.000	0.000	2.82	2.82	0.000	-0.501	0.980	0.057	3.04	25.21
	6	0.106	7.00	692.3	0.085	-0.031	2.61	2.57	-0.005	0.000	2.61	2.56	-0.365	-26.482	1.067	0.091	27.33	28.46
	7	0.106	5.00	697.4	0.118	-0.012	2.44	2.37	0.000	0.000	2.44	2.36	-0.102	-8.770	1.001	0.118	10.09	36.09
	8	0.107	5.00	699.9	0.139	-0.019	2.61	2.52	0.000	0.000	2.61	2 50	-0.137	-10.830	1.007	0.140	11.92	39.08
	9	0.104	15.00	702.4	0.181	-0.053	2.89	2.76	-0.005	-0.001	2.89	2.74	-0.293	-20.221	1.028	0.186	24.99	41.76
	10	0.109	18.00	698.7	0.204	-0.035	2.82	2.67	-0.001	0.000	2.82	2.64	-0.172	-12.686	1.012	0.206	21.90	44.97
4	1	0.106	2.00	638.8	0.168	0.065	2.68	2.56	0.000	0.000	2.68	2.54	0.387	18.076	1.006	0.169	18.18	40.59
	2	0.104	0.00	652.8	0.125	0.060	2.48	2.41	-0.001	0.000	2.48	2.40	0.480	26.696	1.090	0.136	26.70	34.48
	3	0.109	-10.00	663.6	0.086	0.000	2.32	2.28	0.000	0.000	2.32	2.27	0.000	-0.501	0.980	0.084	10.01	30.04
	4	0.107	-8.00	672.9	0.077	-0.016	2.42	2.40	-0.002	0.000	2.42	2.40	-0.208	-14.612	1.016	0.078	16.62	28.28
	5	0.108	-5.00	681.4	0.116	-0.022	2.60	2.53	-0.001	0.000	2.60	2.52	-0.190	-13.634	1.014	0.118	14.51	35.16
	6	0.107	-3.00	697.4	0.140	0.020	2.63	2.53	0.000	0.000	2.63	2.51	0.143	14.416	0.994	0.139	14.72	38.47
	7	0.115	0.00	701.6	0.156	-0.037	2.81	2.71	-0.003	0.000	2.81	2.69	-0.237	-16.321	1.019	0.159	16.32	40.87
	8	0.112	-3.00	703.5	0.171	-0.060	2.97	2.85	-0.005	-0.001	2.97	2.83	-0.351	-25.228	1.054	0.180	25.39	40.99
	9	0.107	14.00	705.3	0.199	-0.050	3.14	2.99	-0.003	-0.001	3.14	2.96	-0.251	-17.216	1.021	0.203	22.06	44.67
	10	0.107	14.00	705.8	0.163	0.019	2.92	2.80	0.000	0.000	2.92	2.78	0.117	11.920	0.988	0.161	18.31	40.76
5	1	0.107	5.00	660	0.238	0.033	3.25	3.07	0.000	0.000	3.25	3.04	0.139	14.039	0.993	0.236	14.89	49.25
	2	0.111	-5.00	675.4	0.198	0.080	3.23	3.09	0.000	0.000	3.23	3.07	0.404	18.359	1.008	0.200	19.00	44.57
	3	0.107	-5.00	682.3	0.195	0.085	3.02	2.87	0.000	0.000	3.02	2.84	0.436	20.176	1.017	0.198	20.76	44.09
	4	0.112	-10.00	688.9	0.219	0.032	3.04	2.87	0.000	0.000	3.04	2.84	0.146	14.703	0.995	0.218	17.72	47.22
	5	0.119	-10.00	693.6	0.215	0.051	2.94	2.77	0.000	0.000	2.94	2.74	0.237	19.762	1.015	0.218	22.06	46.07
	6	0.113	-12.00	697.6	0.213	0.003	3.01	2.85	0.000	0.000	3.01	2.82	0.014	0.928	0.978	0.208	12.04	47.58
	7	0.114	-13.00	700.3	0.213	-0.007	3.06	2.89	0.000	0.000	3.06	2.86	-0.033	-3.588	0.986	0.210	13.48	47.56
	8	0.109	-3.00	702.6	0.217	-0.025	3.17	3.00	0.000	0.000	3 17	2.97	-0.115	-9.600	1.004	0.218	10.05	49.08
	9	0.119	3.00	704.3	0.222	0.014	3.05	2.88	0.000	0.000	3.05	2.85	0.063	6.204	0.978	0.217	6.89	49.45
	10	0.118	-7.00	705.2	0.088	0.000	2.73	2.69	0.000	0.000	2.73	2.68	0.000	-0.501	0.980	0.086	7.02	31.17
6	1	0.121	-10.00	668.7	0.261	0.042	3.10	2.89	0.000	0.000	3.10	2.85	0.161	15.926	0.999	0.261	18.74	50.88
	2	0.112	-10.00	681	0.253	0.085	3.02	2.81	0.000	0.000	3.02	2.77	0.336	18.791	1.010	0.255	21.20	49.87
	3	0.107	-5.00	690	0.278	0.038	3.10	2.87	0.000	0.000	3.10	2.83	0.137	13.859	0.993	0.276	14.72	53.98
	4	0.111	0.00	696.3	0.275	0.024	3.15	2.92	0.000	0.000	3.15	2.88	0.087	8.851	0.982	0.270	8.85	54.69
	5	0.115	-5.00	701	0.284	0.049	3.23	2.99	0.000	0.000	3.23	2.95	0.173	16.790	1.001	0.284	17.50	54.28
	6	0.117	0.00	703.8	0.291	0.020	3.04	2.80	0.000	0.000	3.04	2.76	0.069	6.827	0.979	0.285	6.83	56.64
	7	0.113	4.00	705.6	0.259	-0.001	3.03	2.82	0.000	0.000	3.03	2.78	-0.004	-0.882	0.980	0.254	4.10	53.76
	8	0.112	-3.00	706.9	0.225	-0.026	3.04	2.86	0.000	0.000	3.04	2.83	-0.116	-9.621	1.004	0.226	10.07	50.08
	9	0.116	-2.00	707.3	0.154	-0.017	3.03	2.93	0.000	0.000	3.03	2.91	-0.110	-9.310	1.003	0.154	9.52	41.48
	10	0.109	0.00	701.5	0.078	-0.029	3.16	3.14	-0.004	0.000	3.16	3.14	-0.372	-27.119	1.074	0.084	27.12	27.49

Avg. Duct Static = 2.65

	Average Temp.
Yaw Avg. = 0.57	
Std. Dev. = 7.48	685

		Traverse Avg. Velo
Pitch Avg. = -2.46	Result Angle Avg. = 16.59	
Std. Dev. = 16 82	Std. Dev. = 7.99	37.86

INTERMOUNTAIN OFA (14' probe)1

IP7_037091

Probes Point Velocity
33.03
34.51
34.13
34.07
35.12
34.40
34.29
35.00
33.90
34.90
33.83
34.10
34.43
33.55
34.13
34.37
33.46
35.18
34.91
34.11
34.23
34.62
34.43
34.38
34.48
34.64
34.72
34.92
34.45
35.22
33.82
33.72
34.70
34.51
34.80
34.88
36.22
35.76
34.98
34.99
34.29
35.16
34.63
35.54
36.71
35.83
36.03
35.26
36.87
36.74
36.61
35.42
34.75
35.49
36.19
36.56
35.96
35.81
36.45
35.23

Probes
›city in ft/s
34.92

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68			
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92			
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000 Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		686			
AVERAGE PRESSURE IN. W.C. (Pg)		2.15			
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50			
% O2 (20.95)		20.95			
% N2 (78.09)		78.09			
% CO2 (0.03)		0.03			
% CO (0.0)		0.00			
%A (0.93)		0.93			
% H2O (0.0)		0.00			

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.66	25.66	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	41.95	40.47	
ACTUAL STACK VOLUME (Q acfm) =	157,294	151,771	-3.51
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	62,163	59,980	-3.51
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	62,163	59,980	-3.51
FLOW IN LBS/HR (wet) =	280225	270385	-3.51
FLOW IN LBS/HR (dry) =	280225	270385	-3.51

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029692
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037094

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.138	2.00	623.7	0.074	0.000	2.17	2.14	0.000	0.000	2.17	2.13	0.000	-0.501	0.980	0.072	2.06	27.78
	2	0.146	0.00	637.5	0.081	0.000	2.15	2.11	0.000	0.000	2.15	2.10	0.000	-0.501	0.980	0.079	0.50	29.27
	3	0.139	0.00	653.8	0.109	-0.011	2.43	2.37	0.000	0.000	2.43	2.36	-0.101	-8.720	1.001	0.109	8.72	34.16
	4	0.135	0.00	663.7	0.058	0.000	2.27	2.26	0.000	0.000	2.27	2.26	0.000	-0.501	0.980	0.057	0.50	25.05
	5	0.141	-5.00	672.8	0.076	-0.037	2.12	2.10	0.005	0.000	2.12	2.10	-0.487	-32.999	1.178	0.090	33.33	26.39
	6	0.148	-10.00	683.4	0.112	-0.063	2.04	1.98	-0.005	-0.001	2.04	1.97	-0.563	-25.677	1.058	0.119	27.43	32.41
	7	0.145	2.00	687.6	0.142	-0.050	2.23	2.14	-0 005	-0.001	2.23	2.12	-0.352	-25.340	1.055	0.150	25.41	37.14
	8	0.158	13.00	693.9	0.199	-0.137	2.40	2.25	0.000	0.000	2.40	2.22	-0.688	2.158	0.977	0.194	13.17	45.73
	9	0.143	15.00	698.9	0.223	-0.074	2.55	2.37	-0.006	-0.001	2.55	2.34	-0.332	-23.514	1.042	0.232	27.66	45.56
	10	0.150	0.00	698.6	0.057	0.000	2.20	2.20	0.000	0.000	2.20	2.20	0.000	-0.501	0.980	0.056	0.50	25.22
2	1	0.144	17.00	654.2	0.181	0.039	2.49	2.36	0.000	0.000	2.49	2.34	0.215	19.131	1.011	0.183	25.38	40.45
	2	0.144	0.00	666.4	0.131	0.050	2.32	2.25	0.000	0.000	2.32	2.24	0.382	18.062	1.006	0.132	18.06	36.33
	3	0.151	-5.00	677.5	0.086	0.000	2.16	2.13	0.000	0.000	2.16	2.12	0.000	-0.501	0.980	0.084	5.02	30.58
	4	0.137	0.00	682.8	0.052	0.000	2.10	2.10	0.000	0.000	2.10	2.10	0.000	-0.501	0.980	0.051	0.50	23.93
	5	0.143	-5.00	688.1	0.056	0.022	2.01	2.00	0.000	0.000	2.01	2.00	0.393	18.130	1.007	0.056	18.78	23.89
	6	0.141	-5.00	692.6	0.083	-0.008	2.08	2.05	0.000	0.000	2.08	2.04	-0.096	-8.429	1.000	0.083	9.79	30.23
	7	0.141	0.00	697	0.125	0.050	2.25	2.17	0.000	0.000	2.25	2.16	0.400	18.256	1.007	0.126	18.26	35.94
	8	0.138	1.00	699.7	0.182	-0.106	2.37	2.23	-0.006	-0.001	2.37	2.21	-0.582	-21.713	1.033	0.188	21.73	43.00
	9	0.144	10.00	702.4	0.223	-0.053	2.28	2.10	-0.003	-0.001	2.28	2.07	-0.238	-16.351	1.019	0.227	19.09	48.18
	10	0.144	10.00	702.3	0.121	0.061	2.11	2.04	0.001	0.000	2.11	2.03	0.504	32.810	1.246	0.151	34.14	34.37
3	1	0.140	15.00	645.6	0.200	0.107	2.23	2.08	-0.033	-0.008	2.24	2.05	0.535	43.645	1.228	0.246	45.65	36.13
	2	0.146	0.00	660.3	0.127	0.050	2.04	1.96	0.000	0.000	2.04	1.95	0.394	18.142	1.007	0.128	18.14	35.67
	3	0.151	-7.00	672.8	0.072	0.000	1.97	1.95	0.000	0.000	1.97	1.95	0.000	-0.501	0.980	0.071	7.02	27.83
	4	0.143	0.00	679.7	0.068	0.000	2.12	2.10	0.000	0.000	2.12	2.10	0.000	-0.501	0.980	0.067	0.50	27.33
	5	0.139	-10.00	686.4	0.074	0.022	2.06	2.04	0.000	0.000	2.06	2.04	0.297	19.701	1.014	0.075	22.00	26.97
	6	0.150	-12.00	691.8	0.106	-0.030	2.26	2.20	-0.005	-0.001	2.26	2.19	-0.283	-19.463	1.026	0.109	22.74	32.36
	7	0.143	-7.00	696.3	0.149	-0.016	2.13	2.03	0.000	0.000	2.13	2.01	-0.107	-9.126	1.002	0.149	11.48	40.39
	8	0.137	2.00	700.5	0.184	-0.112	2.11	1.98	-0.002	0.000	2.11	1.96	-0.609	-15.440	1.018	0.187	15.57	44.55
	9	0.145	5.00	702.4	0.237	-0.137	2.21	2.02	-0.006	-0.001	2.21	1.99	-0.578	-22.646	1.037	0.246	23.16	48.74
	10	0.136	20.00	704.3	0.225	0.016	2.17	1.99	0.000	0.000	2.17	1.96	0.071	7.089	0.979	0.220	21.17	46.85
4	1	0.139	3.00	662.7	0.227	0.055	2.24	2.06	0.000	0.000	2.24	2.03	0.242	19.855	1.015	0.230	20.07	47.38
	2	0.142	-5.00	676.2	0.152	0.050	2.19	2.08	0.000	0.000	2.19	2.06	0.329	18.969	1.010	0.154	19.59	39.03
	3	0.141	-4.00	682.5	0.107	0.050	2.07	2.02	-0.001	0.000	2.07	2.01	0.467	24.245	1.053	0.113	24.55	32.37
	4	0.145	-8.00	688.6	0.122	0.027	2.20	2.13	0.000	0.000	2.20	2.12	0.221	19.338	1.012	0.124	20.87	34.90
	5	0.147	-2.00	693.1	0.145	0.003	2.34	2.25	0.000	0.000	2.34	2.23	0.021	1.616	0.977	0.142	2.57	40.04
	6	0.148	-7.00	696.9	0.166	0.088	2.12	2.01	-0.014	-0.003	2.12	1.99	0.530	41.701	1.370	0.227	42.18	37.70
	7	0.146	-5.00	699.2	0.188	-0.016	2.13	1.99	0.000	0.000	2.13	1.97	-0.085	-7.675	0.998	0.188	9.15	45.67
	8	0.153	-6.00	701.5	0.225	-0.095	2.21	2.03	0.002	0.001	2.21	2.00	-0.422	-31.165	1.140	0.257	31.68	46.08
	9	0.142	4.00	703.7	0.259	-0.125	2.42	2.20	0.006	0.002	2.42	2.16	-0.483	-33.065	1.180	0.306	33.28	49.43
	10	0.145	13.00	704.7	0.252	0.005	2.50	2.29	0.000	0.000	2.50	2.25	0.020	1.527	0.977	0.246	13.09	51.73
5	1	0.147	2.00	657.4	0.288	0.128	2.48	2.23	0.000	0.000	2.48	2.19	0.444	21.029	1.023	0.295	21.12	53.06
	2	0.153	-5.00	669.6	0.245	0.050	2.56	2.36	0.000	0.000	2.56	2.33	0 204	18.649	1.009	0.247	19.28	49.45
	3	0.150	-13.00	680.6	0.235	0.050	2.48	2.29	0.000	0.000	2.48	2.26	0.213	19.026	1.011	0.238	22.91	47.54
	4	0.148	-13.00	687.8	0.249	0.050	2.28	2.08	0.000	0.000	2.28	2.05	0.201	18.491	1.008	0.251	22.47	49.20
	5	0.141	-10.00	693.3	0.256	0.006	2.46	2.25	0.000	0.000	2.46	2.21	0 023	1.905	0.977	0.250	10.18	52.42
	6	0.153	-10.00	696.9	0.262	0.058	2.25	2.04	0.000	0.000	2.25	2.00	0.221	19.340	1.012	0.265	21.68	51.06
	7	0.154	-7.00	700.3	0.272	-0.010	2.35	2.13	0.000	0.000	2.35	2.09	-0.037	-3.929	0.987	0.268	8.02	54.81
	8	0.146	-4.00	702	0.267	-0.024	2.35	2.13	0.000	0.000	2.35	2.09	-0.090	-8.000	0.999	0.267	8.94	54.54
	9	0.148	5.00	703.5	0.278	-0.048	2.32	2.09	-0.001	0.000	2.32	2.05	-0.173	-12.743	1.012	0.281	13.67	55.14
	10	0.148	0.00	703.9	0.035	0.000	2.00	2.02	0.000	0.000	2.00	2.02	0.000	-0 501	0.980	0.034	0.50	19.81
6	1	0.152	0.00	648.8	0.334	-0.050	2.74	2.46	0.000	0.000	2.74	2.41	-0.150	-11.536	1.009	0.337	11.54	59.38
	2	0.143	-3.00	671.1	0.326	0.053	2.77	2.49	0.000	0.000	2.77	2.44	0.163	16.055	0.999	0.326	16.33	57.74
	3	0.148	-10.00	685.2	0.319	0.096	2.67	2.40	0.000	0.000	2.67	2.35	0.301	19.630	1.014	0.323	21.94	55.96
	4	0.149	0.00	693	0.356	0.038	2.73	2.42	0.000	0.000	2.73	2.37	0.107	10.917	0.986	0.351	10.92	61.92
	5	0.150	5.00	699.7	0.342	0.047	2.59	2.29	0.000	0.000	2.59	2.24	0.137	13.927	0.993	0.340	14.78	60.16
	6	0.147	10.00	702.1	0.345	-0.043	2.65	2.35	0.000	0.000	2.65	2.30	-0.125	-10.152	1.005	0.347	14.21	61.02
	7	0.145	5.00	704.1	0.321	-0.106	2.83	2.56	-0.006	-0.002	2.83	2.51	-0.330	-23.370	1.041	0.334	23.87	56.52
	8	0.157	7.00	706	0.280	0.002	2.65	2.41	0.000	0.000	2.65	2.37	0.007	0.217	0.979	0.274	7.00	55.62
	9	0.146	5.00	706.7	0.212	-0.033	2.48	2.31	-0.001	0.000	2.48	2.28	-0.156	-11.852	1.010	0.214	12.85	48.31
	10	0.153	0.00	705.2	0.192	-0.133	2.56	2.41	0.000	0.000	2.56	2.38	-0.693	2.461	0.977	0.188	2.46	46.30

Avg. Duct Static = 2.15

	Average Temp.
Yaw Avg. = -0.12	
Std. Dev. = 7.69	686

Pitch Avg. = 1.64	Result Angle Avg. = 16.65	Traverse Avg. Velo
Std. Dev. = 18.21	Std. Dev. = 10.44	41.95

INTERMOUNTAIN OFA (14' probe)1

IP7_037095

Probes Point Velocity
38.35
39.70
39.01
38.62
39.63
40.80
40.45
42.34
40.36
41.34
39.71
39.93
41.10
39.24
40.19
39.98
40.05
39.67
40.58
40.58
39.02
40.12
41.02
40.04
39.59
41.22
40.33
39.55
40.72
39.47
39.18
39.84
39.81
40.47
40.82
41.04
40.81
41.81
40.31
40.75
40.19
41.21
41.01
40.88
39.99
41.73
41.92
40.85
41.16
41.16
40.70
39.87
40.81
41.09
41.35
40.98
40.72
42.41
40.92
41.86

Probes
ocity in ft/s
40.47

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		659				
AVERAGE PRESSURE IN. W.C. (Pg)		3.62				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.77	25.77	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	24.41	20.14	
ACTUAL STACK VOLUME (Q acfm) =	93,997	77,534	-17.51
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	38,201	31,510	-17.52
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	38,201	31,510	-17.52
FLOW IN LBS/HR (wet) =	172207	142044	-17.52
FLOW IN LBS/HR (dry) =	172207	142044	-17.52

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030534
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037098

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.039	0.00	630.2	0.044	0.000	3.73	3.73	0.000	0.000	3.73	3.73	0.000	-0.501	0.980	0.043	0.50	21.45
	2	0.039	5.00	637.8	0.051	-0.023	3.79	3.80	0.005	0.000	3.79	3.80	-0.451	-32.650	1.171	0.060	32.99	21.25
	3	0.039	5.00	645.8	0.046	-0.034	3.73	3.74	0.000	0.000	3.73	3.74	-0.739	-6.256	0.994	0.046	8.00	22.03
	4	0.037	-3.00	652.5	0.049	0.000	3.77	3.78	0.000	0.000	3.77	3.78	0.000	-0.501	0.980	0.048	3.04	22.83
	5	0.036	3.00	661.8	0.061	0.000	3.96	3.96	0.000	0.000	3 96	3.96	0.000	-0.501	0.980	0.060	3.04	25.57
	6	0.038	0.00	668.5	0.046	0.000	3.87	3.87	0.000	0.000	3.87	3.87	0.000	-0.501	0.980	0.045	0.50	22.31
	7	0 039	0.00	676.5	0.060	0.000	3.69	3.68	0.000	0.000	3.69	3.68	0.000	-0.501	0.980	0.059	0.50	25.57
	8	0.038	3.00	681.7	0.059	0.000	3.70	3.70	0.000	0.000	3.70	3.70	0.000	-0.501	0.980	0.058	3.04	25.38
	9	0.039	3.00	683	0.022	0.000	3.58	3.61	0.000	0.000	3.58	3.62	0.000	-0.501	0.980	0.022	3.04	15.51
	10	0.035	3.00	629.7	0.032	0.000	3.54	3.57	0.000	0.000	3.54	3.58	0.000	-0.501	0.980	0.031	3.04	18.27
2	1	0.032	-5.00	642.3	0.025	0.000	3.54	3.57	0.000	0.000	3.54	3.58	0.000	-0.501	0.980	0.024	5.02	16.20
	2	0.034	-5.00	648.3	0.025	0.000	3.58	3.61	0.000	0.000	3.58	3.62	0.000	-0.501	0.980	0.024	5.02	16.24
	3	0.039	-3.00	653.9	0.029	0.007	3.70	3.72	0.000	0.000	3.70	3.72	0.241	19.839	1.015	0.029	20.06	16.83
	4	0.032	-3.00	660.8	0.032	0.000	3.56	3.58	0.000	0.000	3.56	3.58	0.000	-0.501	0.980	0.031	3.04	18.52
	5	0.039	0.00	668.7	0.042	-0.003	3.54	3.55	0.000	0.000	3.54	3.55	-0.071	-6.703	0.995	0.042	6.70	21.35
	6	0.040	7.00	675	0.056	-0.006	3.46	3.46	0.000	0.000	3.46	3.46	-0.107	-9.111	1.002	0.056	11.47	24.48
	7	0.037	5.00	679.3	0.059	-0.042	3.51	3.50	0.000	0.000	3.51	3.50	-0.712	1.949	0.977	0.058	5.37	25.25
	8	0.032	5.00	683.4	0.065	0.000	3.59	3.57	0.000	0.000	3.59	3.57	0.000	-0.501	0.980	0.064	5.02	26.60
	9	0.035	0.00	685.3	0.039	-0.030	3.58	3.60	0.002	0.000	3.58	3.60	-0.769	-31.226	1.141	0.045	31.23	19.11
	10	0.040	0.00	617.6	0.045	0.000	3.62	3.63	0.000	0.000	3.62	3.63	0.000	-0.501	0.980	0.044	0.50	21.57
3	1	0.038	3.00	631.5	0.028	0.000	3.55	3.58	0.000	0.000	3.55	3.59	0.000	-0.501	0.980	0.027	3.04	17.10
	2	0.038	-10.00	639.3	0.030	0.000	3.49	3.52	0.000	0.000	3.49	3.53	0.000	-0.501	0.980	0.029	10.01	17.52
	3	0.037	0.00	648.3	0.040	0.000	3.58	3.59	0.000	0.000	3.58	3.59	0.000	-0.501	0.980	0.039	0.50	20.62
	4	0.038	0.00	657.9	0.045	-0.033	3.58	3.60	0.000	0.000	3.58	3.60	-0.733	-3.579	0.986	0.044	3.58	22.00
	5	0.038	5.00	663.8	0.048	0.000	3.76	3.77	0.000	0.000	3.76	3.77	0.000	-0.501	0.980	0.047	5.02	22.66
	6	0.040	0.00	669.6	0.052	-0.015	3.79	3.79	-0.005	0.000	3.79	3.79	-0.288	-19.880	1.027	0.053	19.88	22.85
	7	0.035	0.00	674.9	0.070	-0.012	3.63	3.61	-0.001	0.000	3.63	3.61	-0.171	-12.678	1.012	0.071	12.68	27.37
	8	0.039	0.00	679.8	0.078	0.000	3.67	3.65	0.000	0.000	3.67	3.65	0.000	-0.501	0.980	0.076	0.50	29.20
	9	0.039	-5.00	683.1	0.064	-0.039	3.63	3.62	-0.002	0.000	3.63	3.62	-0.609	-15.266	1.017	0.065	16.05	25.95
	10	0.039	0.00	595.8	0.067	0.000	3.80	3.79	0.000	0.000	3.80	3.79	0.000	-0.501	0.980	0.066	0.50	26.04
4	1	0.039	-2.00	620.1	0.047	0.000	3.64	3.64	0.000	0.000	3.64	3.64	0.000	-0.501	0.980	0.046	2.06	22.05
	2	0.038	2.00	630.1	0.043	0.000	3.64	3.65	0.000	0.000	3.64	3.65	0.000	-0.501	0.980	0.042	2.06	21.19
	3	0.039	10.00	638.3	0.052	0.000	3.56	3.56	0.000	0.000	3.56	3.56	0.000	-0.501	0.980	0.051	10.01	23.05
	4	0.038	0.00	646.5	0.065	0.023	3.68	3.67	0.000	0.000	3.68	3.67	0.354	18.379	1.008	0.066	18.38	25.28
	5	0.037	0.00	666.9	0.070	0.000	3.63	3.61	0.000	0.000	3.63	3.61	0.000	-0.501	0.980	0.069	0.50	27.51
	6	0.037	8.00	672.8	0.079	0.000	3.61	3.59	0.000	0.000	3.61	3.59	0.000	-0.501	0.980	0.077	8.02	29.02
	7	0.037	0.00	677.4	0.079	-0.044	3.66	3.63	-0.004	0.000	3.66	3.62	-0.557	-26.635	1.068	0.084	26.63	27.41
	8	0.038	3.00	682	0.088	-0.048	3.57	3.54	-0.002	0.000	3.57	3.53	-0.545	-28.410	1.092	0.096	28.55	28.79
	9	0.034	7.00	684.9	0.040	-0.006	3.40	3.42	0.000	0.000	3.40	3.42	-0.150	-11.551	1.009	0.040	13.48	20.69
	10	0.040	0.00	619.7	0.110	0.045	3.63	3.57	0.000	0.000	3.63	3.56	0.409	18.523	1.008	0.111	18.52	32.47
5	1	0.036	0.00	635.2	0.081	0.000	3.44	3.42	0.000	0.000	3.44	3.42	0.000	-0.501	0.980	0.079	0.50	29.18
	2	0.033	0.00	647.7	0.097	0.000	3.52	3.47	0.000	0.000	3.52	3.46	0 000	-0.501	0.980	0.095	0.50	32.11
	3	0.034	7.00	659.3	0.108	0.008	3.59	3.54	0.000	0.000	3.59	3.53	0.074	7.414	0.980	0.106	10.18	33.52
	4	0.036	3.00	666	0.109	0.038	3.48	3.42	0.000	0.000	3.48	3.41	0.349	18.490	1.008	0.110	18.72	32.98
	5	0.037	5.00	672.3	0.104	0.023	3.51	3.46	0.000	0.000	3.51	3.45	0.221	19.333	1.012	0.105	19.94	32.13
	6	0.036	5.00	678.8	0.107	0.001	3.49	3.44	0.000	0.000	3.49	3.43	0 009	0.441	0.978	0.105	5.02	34.05
	7	0.034	0.00	683.2	0.104	-0.027	3.54	3.49	-0.004	0.000	3.54	3.48	-0.260	-17.776	1.022	0.106	17.78	32.85
	8	0.038	3.00	686.6	0.100	-0.073	3.62	3.57	0.000	0.000	3.62	3.56	-0.730	-2.292	0.983	0.098	3.77	33.15
	9	0.035	0.00	687.3	0.041	0.000	3.73	3.75	0.000	0.000	3.73	3.75	0.000	-0.501	0.980	0.040	0.50	21.24

NO ACSESS TO PORT

Avg. Duct Static = 3.62

Yaw Avg. = 1.31	Average Temp.
Std. Dev. = 3.78	659

Pitch Avg. = -2.72	Result Angle Avg. = 8.74	Traverse Avg. Velo
Std. Dev. = 11.61	Std. Dev. = 8.97	24.41

IP7_037099

Probes Point Velocity
20.40
20.47
20.55
20.07
19.88
20.48
20.83
20.61
20.89
19.33
18.59
19.21
20.62
18.74
20.76
21.09
20.32
18.93
19.81
20.54
20.15
20.23
20.04
20.40
20.44
21.03
19.72
20.86
20.89
20.08
20.31
20.14
20.48
20.29
20.21
20.26
20.30
20.62
19.53
20.57
19.65
18.92
19.31
19.93
20.26
20.04
19.51
20.66
19.83

Probes
ocity in ft/s
20.14

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		675				
AVERAGE PRESSURE IN. W.C. (Pg)		2.70				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.70	25.70	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	33.12	31.32	
ACTUAL STACK VOLUME (Q acfm) =	127,497	120,577	-5.43
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	50,927	48,163	-5.43
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	50,927	48,163	-5.43
FLOW IN LBS/HR (wet) =	229574	217115	-5.43
FLOW IN LBS/HR (dry) =	229574	217115	-5.43

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030010
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037102

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.088	-2.00	659.5	0.037	0.000	2.73	2.75	0.000	0.000	2.73	2.75	0.000	-0.501	0.980	0.036	2.06	19.95
	2	0.088	-2.00	669.6	0.056	0.000	2.80	2.79	0.000	0.000	2.80	2.79	0.000	-0.501	0.980	0.055	2.06	24.65
	3	0.088	0.00	675.9	0.069	0.000	2.54	2.52	0.000	0.000	2.54	2 52	0.000	-0.501	0.980	0.068	0.50	27.46
	4	0.088	0.00	679.5	0.041	0.000	2.53	2.55	0.000	0.000	2.53	2.55	0.000	-0.501	0.980	0.040	0.50	21.20
	5	0.088	0.00	683.4	0.056	-0.012	2.50	2.50	-0.002	0.000	2.50	2.50	-0.214	-14.974	1.017	0.057	14.97	24.43
	6	0.088	2.00	687	0.065	0.000	2.64	2.63	0.000	0.000	2.64	2.63	0.000	-0.501	0.980	0.064	2.06	26.77
	7	0.088	0.00	691.8	0.089	-0.042	2.71	2.67	0 006	0.001	2.71	2.66	-0.472	-33.097	1.180	0.105	33.10	28.88
	8	0.088	5.00	693.9	0.101	0.000	2.62	2.57	0.000	0.000	2.62	2.56	0.000	-0.501	0.980	0.099	5.02	33.36
	9	0.088	-7.00	695.7	0.084	0.000	2.60	2.57	0.000	0.000	2.60	2.56	0.000	-0.501	0 980	0.082	7.02	30.34
	10	0.088	0.00	695.1	0.035	0.000	2.51	2.53	0.000	0.000	2.51	2.53	0.000	-0.501	0.980	0.034	0.50	19.72
2	1	0.088	-7.00	632.2	0.095	0.023	2.59	2.54	0.000	0.000	2.59	2.53	0.242	19.851	1.015	0.096	21.00	30.03
	2	0.088	0.00	650.4	0.069	0.022	2.56	2.55	0.000	0.000	2.56	2.55	0.319	19.224	1.012	0.070	19.22	26.06
	3	0.088	8.00	659.3	0.053	0.025	2.65	2.65	-0.001	0.000	2.65	2.65	0.472	25.038	1.063	0.056	26.21	22.33
	4	0.088	10.00	669.6	0.052	0.000	2.85	2.85	0.000	0.000	2.85	2.85	0.000	-0.501	0.980	0.051	10.01	23.40
	5	0.088	7.00	677.5	0.061	0.029	2.50	2.49	-0.001	0.000	2.50	2.49	0.475	25.752	1.074	0.065	26.62	24.19
	6	0.088	-3.00	682.5	0.088	-0.048	2.62	2.59	-0.002	0.000	2.62	2.58	-0.545	-28.410	1.092	0.096	28.55	28.84
	7	0.088	-3.00	686.9	0.106	0.050	2.66	2.60	-0.001	0.000	2.66	2.59	0.472	25.038	1.063	0.113	25.21	32.24
	8	0.088	-10.00	690.9	0.124	-0.035	2.66	2.59	-0.005	-0.001	2.66	2.58	-0.282	-19.405	1.025	0.127	21.74	35.22
	9	0.088	-12.00	691.5	0.086	0.000	2.95	2.91	0.000	0.000	2.95	2.90	0.000	-0.501	0.980	0.084	12.01	30.18
	10	0.088	-10.00	677.8	0.086	-0.009	2.63	2.59	0.000	0.000	2.63	2.58	-0.105	-8.956	1.002	0.086	13.39	30.19
3	1	0.088	-5.00	620	0.138	0.068	2.92	2.83	0.000	0.000	2.92	2.81	0.493	29.679	1.155	0.159	30.06	35.57
	2	0.088	3.00	635.7	0.109	0.050	2.79	2.73	0.000	0.000	2.79	2.72	0.459	22.868	1.038	0.113	23.05	32.10
	3	0.088	0.00	648.3	0.081	0.000	2.67	2.64	0.000	0.000	2.67	2.63	0.000	-0.501	0.980	0.079	0.50	29.39
	4	0.088	5.00	656.6	0.068	0.000	2.69	2.68	0.000	0.000	2.69	2.68	0.000	-0.501	0.980	0.067	5.02	26.92
	5	0.088	10.00	664	0.061	0.000	2.73	2.72	0.000	0.000	2.73	2.72	0 000	-0 501	0.980	0.060	10.01	25.29
	6	0.088	15.00	671.1	0.071	0.034	2.76	2.74	-0.001	0.000	2.76	2.74	0.479	26.458	1 085	0.077	30.14	25.30
	7	0.088	7.00	676.2	0.089	-0.014	2.92	2.88	-0.001	0.000	2.92	2.87	-0.157	-11.939	1.010	0.090	13.81	30.75
	8	0.088	8.00	682.2	0.114	-0.024	2.87	2.81	-0.002	0.000	2.87	2.80	-0.211	-14.763	1.016	0.116	16.75	34.51
	9	0.088	0.00	687.3	0.147	-0.004	2.72	2.63	0.000	0.000	2.72	2.61	-0.027	-3.084	0.985	0.145	3.08	40.33
	10	0.088	-5.00	687.3	0.076	0.007	2.67	2.65	0.000	0.000	2.67	2.65	0.092	9.372	0.983	0.075	10.61	28.51
4	1	0.088	0.00	635.9	0.176	-0.056	3.07	2.94	-0.006	-0.001	3.07	2.92	-0.318	-22.319	1.035	0.182	22.32	40.95
	2	0.088	0.00	652	0.142	0.050	2.91	2.82	0.000	0.000	2.91	2.80	0.352	18.415	1.008	0.143	18.41	37.50
	3	0.088	0.00	664.4	0.121	0.050	2.77	2.70	0.000	0.000	2.77	2.69	0.413	18.688	1.009	0.122	18.69	34.78
	4	0.088	-4.00	671.7	0.105	0.050	2.70	2.64	-0.001	0.000	2.70	2.63	0.476	25.908	1.076	0.113	26.19	31.80
	5	0.088	0.00	681.2	0.108	0.024	2.75	2.70	0.000	0.000	2.75	2.69	0.222	19.368	1.013	0.109	19.37	33.02
	6	0.088	0.00	685.2	0.114	-0.001	2.82	2.76	0.000	0.000	2.82	2.75	-0.009	-1.361	0.981	0.112	1.36	35.45
	7	0.088	5.00	690	0.125	0.050	3.01	2.93	0.000	0.000	3.01	2.92	0.400	18.256	1.007	0.126	18.91	35.66
	8	0.088	-3.00	693.6	0.133	-0.021	2.95	2.87	-0.001	0.000	2.95	2.86	-0.158	-11.970	1.010	0.134	12.33	38.10
	9	0.088	-3.00	696	0.173	-0.021	2.92	2.80	0.000	0.000	2.92	2.78	-0.121	-9.964	1.005	0.174	10.40	43.68
	10	0.088	-5.00	698.4	0.125	0.050	2.76	2.68	0.000	0.000	2.76	2.67	0.400	18.256	1.007	0.126	18.91	35.80
5	1	0.088	0.00	633	0.218	0.050	3.15	2 98	0.000	0.000	3.15	2.95	0.229	19.578	1.014	0.221	19.58	45.86
	2	0.088	3.00	661.7	0.202	0.100	2.95	2.80	0.000	0.000	2.95	2.77	0.495	30.274	1.170	0.236	30.41	44.00
	3	0.088	5.00	671.3	0.184	0.050	2.90	2.77	0.000	0.000	2.90	2.75	0.272	20.013	1.016	0.187	20.60	42.65
	4	0.088	5.00	678.9	0.172	0.050	2.75	2.62	0.000	0.000	2.75	2.60	0.291	19.814	1.015	0.175	20.41	41.41
	5	0.088	5.00	687.3	0.176	-0.021	2.92	2.79	0 000	0.000	2.92	2.77	-0.119	-9.844	1.005	0.177	11.03	43.80
	6	0.088	7.00	692.9	0.207	-0.026	2.98	2.82	0.000	0.000	2.98	2.79	-0.126	-10.208	1.006	0.208	12.36	47.41
	7	0.088	5.00	696.3	0.175	0.018	3.04	2.91	0.000	0.000	3.04	2.89	0.103	10.512	0.985	0.172	11.63	43.32
	8	0.088	4.00	698.4	0.181	-0.011	3.00	2.86	0.000	0.000	3.00	2.84	-0.061	-5.899	0.993	0.180	7.12	44.85
	9	0.088	0.00	700.2	0.207	-0.025	2.90	2.74	0.000	0.000	2.90	2.71	-0 121	-9.929	1.005	0.208	9.93	47.95
	10	0.088	-5.00	701.1	0.168	-0.075	2.84	2.72	0.005	0.001	2.84	2.70	-0.446	-32.475	1.167	0.196	32.82	39.73

NO ACSESS TO PORT

Avg. Duct Static = 2.70

Yaw Avg. = 0.66
Std. Dev. = 5.52

Average Temp. 675

Pitch Avg. = 3.35
Std. Dev. = 16.91

Result Angle Avg. = 15.15
Std. Dev. = 9.64

Traverse Avg. Velo 33.12

Probes Point Velocity
31.10
31.24
31.34
31.38
31.44
31.48
31.55
31.58
31.61
31.60
30.73
30.98
31.10
31.23
31.36
31.42
31.48
31.54
31.53
31.36
30.54
30.77
30.95
31.06
31.16
31.26
31.32
31.41
31.49
31.49
30.76
30.99
31.17
31.27
31.40
31.45
31.51
31.56
31.60
31.64
30.72
31.13
31.26
31.37
31.48
31.56
31.60
31.63
31.66
31.67

Probes
icity in ft/s
31.32

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	77.000	120.000	77.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		678				
AVERAGE PRESSURE IN. W.C. (Pg)		2.04				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.65	25.65	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	64.167	64.167	
STACK VELOCITY FT/ SEC. (Vs) =	37.14	36.45	
ACTUAL STACK VOLUME (Q acfm) =	143,004	140,335	-1.87
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	56,896	55,834	-1.87
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	56,896	55,834	-1.87
FLOW IN LBS/HR (wet) =	256482	251695	-1.87
FLOW IN LBS/HR (dry) =	256482	251695	-1.87

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029892
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037106

12/23/2010

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.117	20.00	632	0.074	0.000	2.11	2.06	0.000	0.000	2.11	2.05	0.000	-0.501	0.980	0.072	20.01	26.22
	2	0.119	10.00	643.2	0.085	0.000	1.98	1.92	0.000	0.000	1.98	1.91	0.000	-0.501	0.980	0.083	10.01	29.61
	3	0.113	5.00	654.9	0.111	0.050	1.99	1.90	0.000	0.000	1.99	1.88	0.450	21.737	1.028	0.114	22.28	32.74
	4	0.107	5.00	663.3	0.081	0.000	1.98	1.91	0.000	0.000	1.98	1.90	0.000	-0.501	0.980	0.079	5.02	29.50
	5	0.111	20.00	671	0.063	0.000	2.16	2.12	0.000	0.000	2.16	2.11	0.000	-0.501	0.980	0.062	20.01	24.62
	6	0.123	20.00	676.7	0.073	-0.039	2.19	2.14	0 000	0.000	2.19	2.13	-0.534	-29.856	1.115	0.081	35.42	24.59
	7	0.118	10.00	681	0.106	-0.076	2.06	1.98	0.000	0.000	2.06	1.97	-0.717	1.182	0.978	0.104	10.07	33.58
	8	0.116	5.00	686.5	0.117	0.050	2.08	1.99	0.000	0.000	2.08	1.97	0.427	19.492	1.013	0.119	20.10	34.34
	9	0.122	4.00	690.3	0.112	0.050	1.97	1.88	0.000	0.000	1.97	1.86	0.446	21.253	1.024	0.115	21.61	33.50
	10	0.113	0.00	691.5	0.041	0.000	2.09	2.07	0.000	0.000	2.09	2.07	0.000	-0.501	0.980	0.040	0.50	21.33
2	1	0.121	-10.00	664.6	0.179	0.050	2.28	2.12	0.000	0.000	2.28	2.09	0.279	19.958	1.016	0.182	22.23	41.51
	2	0.118	-5.00	673	0.133	0.050	2.30	2.19	0.000	0.000	2.30	2.17	0.376	18.078	1.006	0.134	18.73	36.57
	3	0.117	5.00	679.7	0.087	0.000	2.34	2.27	0.000	0.000	2.34	2.26	0.000	-0.501	0.980	0.085	5.02	30.78
	4	0.123	10.00	684.4	0.057	0.000	2.31	2.28	0.000	0.000	2.31	2.27	0.000	-0.501	0.980	0.056	10.01	24.68
	5	0.129	15.00	688.7	0.052	0.000	2.19	2.16	0.000	0.000	2.19	2.15	0.000	-0.501	0.980	0.051	15.01	23.17
	6	0.117	20.00	692.4	0.070	-0.024	2.11	2.07	-0.006	0.000	2.11	2.06	-0.343	-24.502	1.048	0.073	31.23	24.66
	7	0.120	15.00	695.5	0.101	-0.054	2.14	2.05	0.000	0.000	2.14	2.03	-0.535	-29.809	1.115	0.113	33.06	29.98
	8	0.127	5.00	697.8	0.133	0.050	2.16	2.05	0.000	0.000	2.16	2.03	0.376	18.078	1.006	0.134	18.73	36.98
	9	0.122	-5.00	700.3	0.174	-0.050	2.38	2.22	-0.005	-0.001	2.38	2.19	-0.287	-19.795	1.026	0.179	20.39	42.31
	10	0.126	0.00	700	0.110	-0.077	2.35	2.26	0.000	0.000	2.35	2.24	-0.700	2.657	0.977	0.107	2.66	34.97
3	1	0.127	-8.00	625.4	0.212	-0.014	2.16	1.97	0.000	0.000	2.16	1.94	-0.066	-6.302	0.994	0.211	10.17	46.69
	2	0.115	-5.00	643.4	0.147	0.063	2.18	2.05	0.000	0.000	2.18	2.03	0.429	19.580	1.014	0.149	20.18	37.75
	3	0.115	-2.00	653.8	0.109	0.050	2.19	2.11	0.000	0.000	2.19	2.10	0.459	22.868	1.038	0.113	22.95	32.41
	4	0.115	3.00	662.7	0.076	0.000	2.12	2.07	0.000	0.000	2.12	2.06	0.000	-0.501	0.980	0.074	3.04	28.63
	5	0.113	3.00	668.3	0.067	0.000	1.93	1.89	0.000	0.000	1.93	1.88	0.000	-0.501	0.980	0.066	3.04	26.96
	6	0.111	2.00	674.1	0.081	0.000	1.89	1.83	0.000	0.000	1.89	1.82	0.000	-0.501	0.980	0.079	2.06	29.74
	7	0.114	2.00	680.2	0.099	0.003	1.93	1.86	0.000	0.000	1.93	1.85	0.030	2.635	0.977	0.097	3.31	32.89
	8	0.116	4.00	684.2	0.132	-0.058	1.97	1.86	0.004	0.001	1.97	1.84	-0.439	-32.156	1.160	0.153	32.38	35.08
	9	0.122	-10.00	690.6	0.180	-0.050	2.10	1.93	-0.005	-0.001	2.10	1.90	-0.278	-19.069	1.025	0.184	21.45	42.54
	10	0.122	-5.00	691.9	0.122	0.003	2.10	1.99	0.000	0.000	2.10	1.97	0.025	2.027	0.977	0.119	5.39	36.59
4	1	0.126	-8.00	641.2	0.244	-0.014	2.22	1.99	0.000	0.000	2.22	1.95	-0.057	-5.633	0.992	0.242	9.77	50.46
	2	0.112	5.00	657.6	0.167	0.088	2.18	2.03	-0.007	-0.002	2.18	2.00	0.527	40.484	1.405	0.235	40.74	38.48
	3	0.116	4.00	667.2	0.137	0.050	2.21	2.09	0.000	0.000	2.21	2.07	0.365	18.187	1.007	0.138	18.61	37.06
	4	0.112	5.00	674.1	0.143	-0.054	2.38	2.26	-0.003	-0.001	2.38	2.24	-0.378	-27.637	1.081	0.155	28.05	36.63
	5	0.120	10.00	680.4	0.133	0.057	2.39	2.28	0.000	0.000	2.39	2.26	0.429	19.580	1.014	0.135	21.90	36.07
	6	0.125	6.00	686	0.135	0.047	2.25	2.13	0.000	0.000	2.25	2.11	0.348	18.500	1.008	0.136	19.42	36.94
	7	0.123	10.00	692.1	0.145	-0.043	2.19	2.06	-0.005	-0.001	2.19	2.04	-0.297	-20.518	1.028	0.149	22.73	37.92
	8	0.120	8.00	695.4	0.175	-0.075	2.15	1.99	0.003	0.001	2.15	1.96	-0.429	-31.563	1.148	0.201	32.46	40.33
	9	0.121	2.00	698.3	0.215	-0.153	2.32	2.12	0.000	0.000	2.32	2.09	-0.712	1.978	0.977	0.210	2.81	48.86
	10	0.120	2.00	699.7	0.126	0.023	2.17	2.06	0.000	0.000	2.17	2.04	0.183	17.460	1.004	0.126	17.57	36.22
5	1	0.121	5.00	649.5	0.298	-0.076	2.40	2.12	-0.004	-0.001	2.40	2.07	-0.255	-17.467	1.021	0.304	18.15	54.77
	2	0.130	3.00	666.7	0.248	0.050	2.38	2.15	0.000	0.000	2.38	2.11	0.202	18.531	1.008	0 250	18.76	49.84
	3	0.120	3.00	675.3	0.247	0.050	2.35	2.12	0.000	0.000	2.35	2.08	0.202	18.571	1.009	0.249	18.80	49.93
	4	0.111	0.00	682.3	0.242	0.038	2.48	2.25	0.000	0.000	2.48	2.21	0.157	15.617	0.998	0.241	15.62	50.15
	5	0.119	7.00	688.7	0.240	0.037	2.51	2.29	0.000	0.000	2.51	2 25	0.154	15.384	0.997	0.239	16.87	49.74
	6	0.123	5.00	693.1	0.233	0.050	2.23	2.02	0.000	0.000	2.23	1.98	0 215	19.098	1.011	0.236	19.72	48.67
	7	0.117	5.00	696.4	0.233	0.004	2.25	2.03	0.000	0.000	2.25	1.99	0.017	1.248	0.978	0.228	5.15	50.70
	8	0.119	4.00	698.7	0.229	-0.030	2.19	1.98	0.000	0.000	2.19	1.94	-0.131	-10.514	1.006	0.230	11.24	50.28
	9	0.113	0.00	700.5	0.250	-0.010	2.09	1.86	0 000	0.000	2.09	1.82	-0.040	-4 207	0.988	0.247	4 21	52.97
	10	0.122	1.00	699.8	0.136	-0.052	2.12	2.00	-0.003	0.000	2.12	1 98	-0.382	-28.052	1.086	0.148	28.07	36.23

NO ACSESS TO PORT

Avg. Duct Static = 2.04

	Average Temp.
Yaw Avg. = 4.20	
Std. Dev. = 7.31	678

		Traverse Avg. Velo
Pitch Avg. = 1.23	Result Angle Avg. = 16.73	
Std. Dev. = 17.72	Std. Dev. = 9.93	37.14

Probes Point Velocity
35.45
35.94
35.21
34.39
35.14
37.08
36.40
36.17
37.16
35.77
36.58
36.26
36.21
37.20
38.17
36.42
36.93
38.03
37.31
37.91
36.83
35.33
35.49
35.64
35.42
35.20
35.77
36.14
37.17
37.18
36.95
35.09
35.86
35.34
36.68
37.53
37.34
36.93
37.13
37.00
36.34
37.95
36.61
35.31
36.66
37.35
36.48
36.83
35.93
37.31

Probes
city in ft/s
36.45

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		656				
AVERAGE PRESSURE IN. W.C. (Pg)		3.46				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.75	25.75	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	27.04	18.15	
ACTUAL STACK VOLUME (Q acfm) =	101,396	68,073	-32.86
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	41,310	27,734	-32.86
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	41,310	27,734	-32.86
FLOW IN LBS/HR (wet) =	186222	125022	-32.86
FLOW IN LBS/HR (dry) =	186222	125022	-32.86

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030610
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037110

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1					0.000												
	2	0.029	-20.00	593.1	0.026	0.000	3.45	3.44	0.000	0.000	3.45	3.44	0.000	-0.501	0.980	0.025	20.01	15.23
	3	0.025	0.00	620.4	0.047	-0.033	3.48	3.45	0.000	0.000	3.48	3.44	-0.702	2.630	0.977	0.046	2.63	22.02
	4	0.027	0.00	632.8	0.055	-0.033	3.50	3.47	-0.004	0.000	3.50	3.46	-0.600	-17.620	1.022	0.056	17.62	23.38
	5	0.030	0.00	644.5	0.058	0.000	3.42	3.38	0.000	0.000	3.42	3.37	0.000	-0.501	0.980	0.057	0.50	24.80
	6	0.029	0.00	654.7	0.066	0.005	3.43	3.39	0.000	0.000	3.43	3.38	0.076	7.598	0.980	0.065	7.60	26.35
	7	0.030	0.00	663.2	0.069	-0.050	3.45	3.40	0.000	0.000	3.45	3.39	-0.725	-0.576	0.980	0.068	0.58	27.28
	8	0.031	0.00	669.8	0.069	0.009	3.48	3.43	0.000	0.000	3.48	3.42	0.130	13.275	0.991	0.068	13.28	26.78
	9	0.031	0.00	674.8	0.088	-0.064	3.61	3.55	0.000	0.000	3.61	3.54	-0.727	-1.366	0.981	0.086	1.37	30.97
	10	0.031	-5.00	680.2	0.098	-0.012	3.52	3.44	0.000	0.000	3.52	3.43	-0.122	-10.026	1.005	0.098	11.19	32.54
2	1	0.03	3.00	602.4	0.032	-0.015	3.64	3.63	0.006	0.000	3.64	3.63	-0.469	-33.070	1.180	0.038	33.19	16.58
	2	0.03	-7.00	616.4	0.034	-0.020	3.66	3.64	-0.005	0.000	3.66	3.64	-0.588	-20.413	1.028	0.035	21.53	17.86
	3	0.027	0.00	628.1	0.035	-0.018	3.76	3.75	0.003	0.000	3.76	3.75	-0.514	-31.747	1.152	0.040	31.75	17.62
	4	0.028	3.00	641	0.047	-0.017	3.55	3.52	-0.005	0.000	3.55	3.51	-0.362	-26.210	1.064	0.050	26.37	20.80
	5	0.03	2.00	649.7	0.045	-0.020	3.47	3.45	0.004	0.000	3.47	3.45	-0.444	-32.391	1.165	0.052	32.45	20.15
	6	0.032	3.00	659.6	0.061	-0.018	3.44	3.40	-0.005	0.000	3.44	3.39	-0.295	-20.401	1.028	0.063	20.61	24.55
	7	0.03	0.00	665.6	0.069	-0.023	3.63	3.58	-0.006	0.000	3.63	3.57	-0.333	-23.647	1.042	0.072	23.65	25.79
	8	0.03	-3.00	672.5	0.082	-0.017	3.71	3.65	-0.002	0.000	3.71	3.64	-0.207	-14.586	1.016	0.083	14.88	29.38
	9	0.032	-3.00	677.7	0.097	-0.021	3.82	3.74	-0.002	0.000	3.82	3.73	-0.216	-15.099	1.017	0.099	15.39	31.96
	10	0.03	-10.00	682.6	0.117	-0.011	3.74	3.64	0.000	0.000	3.74	3.62	-0.094	-8.274	1.000	0.117	12.95	35.26
3	1	0.03	-4.00	610.8	0.028	0.005	3.69	3.68	0.000	0.000	3.69	3.68	0.179	17.202	1.003	0.028	17.65	16.35
	2	0.031	0.00	621.9	0.023	-0.001	3.48	3.47	0.000	0.000	3.48	3.47	-0.043	-4.502	0.989	0.023	4.50	15.48
	3	0.029	-2.00	634.5	0.026	0.001	3.43	3.43	0.000	0.000	3.43	3.43	0.038	3.513	0.977	0.025	4.04	16.46
	4	0.029	-10.00	651.9	0.040	-0.001	3.58	3.56	0.000	0.000	3.58	3.56	-0.025	-2.884	0.984	0.039	10.40	20.37
	5	0.031	-2.00	661.7	0.046	0.000	3.70	3.68	0.000	0.000	3.70	3.68	0.000	-0.501	0.980	0.045	2.06	22.23
	6	0.031	-3.00	667.5	0.057	0.000	3.79	3.76	0.000	0.000	3.79	3.75	0.000	-0.501	0.980	0.056	3.04	24.79
	7	0.032	-3.00	672.2	0.065	-0.002	3.56	3.52	0.000	0.000	3.56	3.51	-0.031	-3.403	0.986	0.064	4.54	26.57
	8	0.032	-7.00	678	0.077	0.000	3.49	3.43	0.000	0.000	3.49	3.42	0.000	-0.501	0.980	0.075	7.02	28.79
	9	0.03	-18.00	682.8	0.100	-0.002	3.48	3.40	0.000	0.000	3.48	3.39	-0.020	-2.424	0.983	0.098	18.16	31.53
	10	0.028	-7.00	683.5	0.115	-0.003	3.65	3.55	0.000	0.000	3.65	3.53	-0.026	-2.983	0.985	0.113	7.61	35.30
4	1	0.029	7.00	624.7	0.031	0.009	3.30	3.29	0.000	0.000	3.30	3.29	0.290	19.820	1.015	0.031	20.97	17.08
	2	0.029	0.00	634.1	0.032	0.013	3.31	3.30	0.000	0.000	3.31	3.30	0.406	18.425	1.008	0.032	18.43	17.64
	3	0.028	0.00	642.9	0.042	0.006	3.45	3.43	0.000	0.000	3.45	3.43	0.143	14.416	0.994	0.042	14.42	20.57
	4	0.028	0.00	650.5	0.049	0.009	3.53	3.50	0.000	0.000	3.53	3.49	0.184	17.531	1.004	0.049	17.53	22.06
	5	0.031	0.00	656.9	0.049	0.014	3.39	3.36	0.000	0.000	3.39	3.35	0.286	19.885	1.015	0.050	19.89	21.94
	6	0.032	0.00	663.8	0.067	0.016	3.25	3.21	0.000	0.000	3.25	3.20	0.239	19.793	1.015	0.068	19.79	25.75
	7	0.03	0.00	669.5	0.071	0.010	3.33	3.27	0.000	0.000	3.33	3.26	0.141	14.237	0.994	0.071	14.24	27.09
	8	0.031	0.00	674.2	0.087	0.012	3.31	3.25	0.000	0.000	3.31	3.24	0.138	13.973	0.993	0.086	13.97	30.08
	9	0.03	-5.00	679.2	0.097	0.010	3.29	3.21	0.000	0.000	3.29	3.20	0.103	10.536	0.985	0.096	11.65	31.99
	10	0.028	-5.00	682.5	0.110	0.006	3.50	3.41	0.000	0.000	3.50	3.39	0.055	5.268	0.977	0.108	7.26	34.42
5	1	0.03	3.00	619.5	0.037	-0.007	3.27	3.25	-0.001	0.000	3.27	3.25	-0.189	-13.609	1.014	0.038	13.93	19.34
	2	0.029	3.00	632.7	0.056	0.015	3.45	3.40	0.000	0.000	3.45	3.39	0.268	20.027	1.016	0.057	20.24	23.16
	3	0.031	5.00	643.1	0.080	0.015	3.57	3.51	0.000	0.000	3.57	3.50	0.188	17.765	1.005	0.080	18.43	27.96
	4	0.031	3.00	651.9	0.097	0.022	3.47	3.39	0.000	0.000	3.47	3.38	0.227	19.507	1.013	0.098	19.73	30.80
	5	0.032	0.00	659.2	0.105	0.031	3.53	3.45	0.000	0.000	3.53	3.44	0.295	19.738	1.015	0.107	19.74	32.17
	6	0.032	3.00	665.9	0.107	0.034	3.49	3.40	0.000	0.000	3.49	3.38	0.318	19.251	1.012	0.108	19.47	32.58
	7	0.031	0.00	671.1	0.112	0.040	3.42	3.33	0.000	0.000	3.42	3.31	0.357	18.315	1.007	0.113	18.32	33.58
	8	0.033	-7.00	675.9	0.109	0.043	3.48	3.39	0.000	0.000	3.48	3.37	0.394	18.153	1.007	0.110	19.41	32.96
	9	0.031	-10.00	681.5	0.103	0.028	3.65	3.56	0.000	0.000	3.65	3.54	0.272	20.012	1.016	0.105	22.28	31.65
	10	0.031	-9.00	683.9	0.082	0.014	3.57	3.51	0.000	0.000	3.57	3.50	0.171	16.662	1.001	0.082	18.88	28.70
6	1	0.031	-10.00	620.9	0.103	0.001	3.63	3.54	0.000	0.000	3.63	3.52	0.010	0.478	0.978	0.101	10.01	32.17
	2	0.033	0.00	635.9	0.095	0.011	3.57	3.49	0.000	0.000	3.57	3.48	0.116	11.842	0.988	0.094	11.84	31.07
	3	0.029	0.00	646.8	0.136	0.026	3.59	3.47	0.000	0.000	3.59	3.45	0.191	17.979	1.006	0.137	17.98	36.64
	4	0.03	0.00	658.8	0.152	0.049	3.64	3.51	0.000	0.000	3.64	3.49	0.322	19.136	1.011	0.154	19.14	38.78
	5	0.032	-2.00	666	0.138	0.055	3.63	3.51	0.000	0.000	3.63	3.49	0.399	18.225	1.007	0.139	18.33	37.17
	6	0.031	-3.00	671.4	0.140	0.069	3.71	3.59	0.000	0.000	3.71	3.57	0.493	29.705	1.155	0.162	29.84	36.72
	7	0.032	-2.00	675.6	0.121	0.007	3.57	3.47	0.000	0.000	3.57	3.45	0.058	5.631	0.978	0.118	5.97	36.08
	8	0.029	-4.00	678.6	0.110	0.025	3.47	3.38	0.000	0.000	3.47	3.36	0.227	19.521	1.013	0.111	19.91	33.16
	9	0.029	-5.00	681.9	0.099	0.045	3.43	3.34	0.000	0.000	3.43	3.32	0.455	22.274	1.032	0.102	22.80	31.18
	10	0.032	-4.00	684	0.105	0.007	3.45	3.36	0.000	0.000	3.45	3.34	0.067	6.600	0.979	0.103	7.71	33.64

Avg. Duct Static = 3.46

Yaw Avg. = -2.29	Average Temp.
Std. Dev. = 4.99	656

Pitch Avg. = 3.92	Result Angle Avg. = 15.23	Traverse Avg. Velo
Std. Dev. = 15.98	Std. Dev. = 8.04	27.04

IP7_037111

Probes Point Velocity
17.30
16.27
17.00
18.02
17.80
18.17
18.52
18.56
18.61
17.67
17.78
16.96
17.38
18.06
18.74
18.19
18.24
18.88
18.32
17.73
18.13
17.63
17.77
18.45
18.50
18.84
18.89
18.33
17.71
17.56
17.63
17.39
17.45
18.42
18.78
18.23
18.57
18.30
17.70
17.82
17.62
18.30
18.38
18.73
18.79
18.54
19.17
18.62
18.64
18.12
18.82
17.73
18.13
18.79
18.53
18.87
17.99
18.02
18.94

Probes
ɔcity in ft/s
18.15

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		656				
AVERAGE PRESSURE IN. W.C. (Pg)		2.59				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.69	25.69	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	36.49	30.88	
ACTUAL STACK VOLUME (Q acfm) =	136,831	115,793	-15.38
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	55,577	47,032	-15.38
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	55,577	47,032	-15.38
FLOW IN LBS/HR (wet) =	250536	212016	-15.38
FLOW IN LBS/HR (dry) =	250536	212016	-15.38

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.030517
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037114

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.088	-12.00	637.5	0.040	-0.014	2.80	2.78	-0.005	0.000	2.80	2.78	-0.350	-25.148	1.053	0.042	27.70	18.87
	2	0.085	5.00	589.4	0.043	-0.017	2.55	2.52	-0.001	0.000	2.55	2.51	-0.395	-29.155	1.103	0.047	29.54	19.24
	3	0.086	8.00	604.2	0.091	-0.058	2.67	2.59	0.000	0.000	2.67	2.58	-0.637	-7.942	0.999	0.091	11.25	30.23
	4	0.084	5.00	619.2	0.106	-0.064	2.81	2.71	-0.003	0.000	2.81	2.69	-0.604	-16.684	1.020	0.108	17.40	32.30
	5	0.086	2.00	633.3	0.103	-0.074	2.82	2.73	0.000	0.000	2.82	2.71	-0.718	0.904	0.978	0.101	2.19	32.86
	6	0.087	0.00	642.8	0.128	-0.053	2.77	2.65	0.001	0.000	2.77	2.63	-0.414	-30.604	1.129	0.145	30.60	34.05
	7	0.085	0.00	653.9	0.141	-0.047	2.63	2.50	-0.006	-0.001	2.63	2.48	-0.333	-23.647	1.042	0.147	23.65	36.74
	8	0.083	10.00	661.6	0.143	-0.033	2.62	2.49	-0.003	0.000	2.62	2.47	-0.231	-15.931	1.019	0.146	18.74	37.94
	9	0.087	18.00	666.9	0.170	-0.028	2.67	2.52	-0.001	0.000	2.67	2.49	-0.165	-12.327	1.011	0.172	21.70	40.53
	10	0.086	5.00	672.2	0.180	0.001	2.70	2.53	0.000	0.000	2.70	2.50	0.006	0.056	0.979	0.176	5.00	44.10
2	1	0.086	-5.00	623.3	0.043	-0.026	2.45	2.42	-0.003	0.000	2.45	2.41	-0.605	-16.464	1.020	0.044	17.19	20.64
	2	0.088	-8.00	625.3	0.047	-0.028	2.47	2.44	-0.004	0.000	2.47	2.43	-0.596	-18.654	1.024	0.048	20.24	21.25
	3	0.085	-2.00	629.8	0.058	-0.027	2.59	2.55	0.006	0.000	2.59	2.54	-0.466	-33.027	1.179	0.068	33.08	22.67
	4	0.083	8.00	638.1	0.065	-0.021	2.71	2.66	-0.006	0.000	2.71	2.65	-0.323	-22.743	1.037	0.067	24.04	24.62
	5	0.085	-6.00	646.3	0.054	-0.013	2.64	2.60	-0.003	0.000	2.64	2.59	-0.241	-16.542	1.020	0.055	17.57	23.32
	6	0.087	0.00	654.5	0.089	-0.014	2.56	2.48	-0.001	0.000	2.56	2.47	-0.157	-11.939	1.010	0.090	11.94	30.70
	7	0.087	7.00	704.4	0.124	-0.017	2.55	2.44	0.000	0.000	2.55	2.42	-0.137	-10.853	1.007	0.125	12.89	36.85
	8	0.085	5.00	721.7	0.145	-0.013	2.56	2.43	0.000	0.000	2.56	2.41	-0.090	-7.984	0.999	0.145	9.41	40.46
	9	0.087	10.00	749.4	0.189	0.000	2.63	2.45	0.000	0.000	2.63	2.42	0.000	-0.501	0.980	0.185	10.01	46.19
	10	0.087	25.00	708.8	0.228	0.009	2.80	2.58	0.000	0.000	2.80	2.54	0.039	3.622	0.977	0.223	25.24	45.74
3	1	0.087	2.00	626.9	0.027	-0.006	2.59	2.58	-0.002	0.000	2.59	2.58	-0.222	-15.427	1.018	0.027	15.55	16.50
	2	0.090	-5.00	636	0.031	-0.005	2.67	2.66	-0.001	0.000	2.67	2.66	-0.161	-12.148	1.011	0.031	13.12	17.88
	3	0.089	12.00	646	0.050	0.004	2.79	2.75	0.000	0.000	2.79	2.74	0.080	8.062	0.981	0.049	14.42	22.35
	4	0.085	-4.00	654.8	0.059	0.010	2.70	2.65	0.000	0.000	2.70	2.64	0.169	16.572	1.001	0.059	17.03	24.31
	5	0.090	5.00	660	0.063	0.011	2.66	2.61	0.000	0.000	2.66	2.60	0.175	16.934	1.002	0.063	17.64	25.11
	6	0.089	5.00	664	0.083	0.005	2.70	2.62	0.000	0.000	2.70	2.61	0.060	5.894	0.978	0.081	7.72	29.66
	7	0.085	8.00	667.2	0.108	-0.001	2.68	2.59	0.000	0.000	2.68	2.57	-0.009	-1.408	0.981	0.106	8.12	33.91
	8	0.088	10.00	671.7	0.163	0.000	2.68	2.53	0.000	0.000	2.68	2.50	0.000	-0.501	0.980	0.160	10.01	41.49
	9	0.086	10.00	676.2	0.213	0.009	2.96	2.76	0.000	0.000	2.96	2.73	0.042	3.924	0.977	0.208	10.74	47.33
	10	0.087	28.00	678.5	0.225	0.013	3.04	2.82	0.000	0.000	3.04	2.78	0.058	5.623	0.978	0.220	28.51	43.57
4	1	0.084	10.00	621.7	0.023	0.004	2.61	2.61	0.000	0.000	2.61	2.61	0.174	16.886	1.002	0.023	19.55	14.74
	2	0.087	10.00	637.3	0.037	0.006	2.70	2.68	0.000	0.000	2.70	2.68	0.162	16.023	0.999	0.037	18.82	18.89
	3	0.091	8.00	645.9	0.083	0.015	2.72	2.65	0.000	0.000	2.72	2.64	0.181	17.343	1.003	0.083	19.05	28.43
	4	0.086	6.00	653.7	0.109	0.023	2.93	2.84	0.000	0.000	2.93	2.82	0.211	18.955	1.010	0.110	19.85	32.64
	5	0.090	-3.00	658.7	0.106	0.031	2.80	2.71	0.000	0.000	2.80	2.69	0.292	19.786	1.015	0.108	20.00	32.30
	6	0.087	4.00	664.2	0.124	0.023	2.76	2.65	0.000	0.000	2.76	2.63	0.185	17.643	1.005	0.125	18.08	35.25
	7	0.091	7.00	668.5	0.165	0.024	2.75	2.59	0.000	0.000	2.75	2.56	0.145	14.645	0.995	0.164	16.20	40.96
	8	0.090	7.00	672.2	0.197	0.034	2.72	2.53	0.000	0.000	2.72	2.50	0.173	16.794	1.001	0.197	18.16	44.51
	9	0.088	2.00	675.9	0.239	0.032	2.80	2.58	0.000	0.000	2.80	2.54	0.134	13.600	0.992	0.237	13.74	49.96
	10	0.087	23.00	678.6	0.230	0.012	2.83	2.61	0.000	0.000	2.83	2.57	0.052	5.008	0.977	0.225	23.51	45.97
5	1	0.087	5.00	612.3	0.083	0.007	2.74	2.68	0.000	0.000	2.74	2.67	0.084	8.533	0.981	0.081	9.88	28.85
	2	0.090	2.00	629.4	0.108	0.013	2.69	2.59	0.000	0.000	2.69	2.57	0.120	12.299	0.989	0.107	12.46	33.01
	3	0.087	0.00	642	0.178	0.034	2.74	2.58	0.000	0.000	2.74	2.55	0.191	17.970	1.006	0.179	17.97	41.88
	4	0.084	-2.00	651	0.220	0.050	2.70	2.49	0.000	0.000	2.70	2.45	0.227	19.521	1.013	0.223	19.62	46.47
	5	0.086	5.00	658.9	0.220	0.064	2.81	2.60	0.000	0.000	2.81	2.56	0.291	19.810	1.015	0.223	20.41	46.43
	6	0.091	3.00	665.4	0.216	0.055	2.77	2.57	0.000	0.000	2.77	2.54	0.255	19.997	1.016	0.219	20.21	46.22
	7	0.087	10.00	670.4	0.224	0.055	2.81	2.60	0.000	0.000	2.81	2.56	0.246	19.903	1.015	0.227	22.18	46.53
	8	0.087	15.00	673.8	0.242	0.058	2.92	2.69	0.000	0.000	2.92	2.65	0.240	19.809	1.015	0.246	24.66	47.52
	9	0.087	10.00	676.7	0.223	0.032	3.04	2.83	0.000	0.000	3.04	2.79	0.143	14.473	0.994	0.222	17.53	47.43
	10	0.084	8.00	682.8	0.220	0.011	3.02	2.81	0.000	0.000	3.02	2.77	0.050	4.769	0.977	0.215	9.31	48.46
6	1	0.085	-3.00	603.2	0.205	0.011	2.88	2.68	0.000	0.000	2.88	2.65	0.054	5.170	0.977	0.200	5.98	45.49
	2	0.085	-5.00	626.3	0.162	0.017	2.93	2.78	0.000	0.000	2.93	2.75	0.105	10.729	0.985	0.160	11.82	40.38
	3	0.092	-3.00	645.7	0.279	0.041	2.88	2.62	0.000	0.000	2.88	2.58	0.147	14.775	0.995	0.278	15.07	53.02
	4	0.085	-5.00	653.4	0.284	0.062	2.85	2.58	0.000	0.000	2.85	2.53	0.218	19.235	1.012	0.287	19.85	52.73
	5	0.091	0.00	661.7	0.261	0.072	2.78	2.52	0.000	0.000	2.78	2.48	0.276	19.987	1.016	0.265	19.99	50.80
	6	0.091	3.00	667.9	0.254	0.071	2.86	2.62	0.000	0.000	2.86	2.58	0.280	19.956	1.016	0.258	20.17	50.18
	7	0.090	0.00	671.4	0.233	0.061	2.87	2.65	0.000	0.000	2.87	2.61	0.262	20.029	1.016	0.237	20.03	48.19
	8	0.086	2.00	677.7	0.212	0.041	2.95	2.75	0.000	0.000	2.95	2.72	0.193	18.103	1.007	0.213	18.21	46.38
	9	0.086	5.00	679.8	0.212	0.012	2.79	2.58	0.000	0.000	2.79	2.54	0.057	5.494	0.978	0.207	7.42	47.77
	10	0.087		680.2	0.178	0.025	2.77	2.60										

Avg. Duct Static = 2.59

	Average Temp.
Yaw Avg. = 4.58	656
Std. Dev. = 7.63	

		Traverse Avg. Velo
Pitch Avg. = 3.04	Result Angle Avg. = 17.15	36.49
Std. Dev. = 15.95	Std. Dev. = 6.54	

Probes Point Velocity
30.79
29.60
29.98
29.83
30.38
30.69
30.50
30.24
31.03
30.93
30.26
30.63
30.16
29.92
30.39
30.86
31.55
31.42
32.15
31.60
30.48
31.12
31.09
30.50
31.46
31.34
30.68
31.28
30.97
31.18
29.87
30.62
31.44
30.66
31.44
30.99
31.76
31.64
31.33
31.19
30.27
31.03
30.69
30.28
30.74
31.72
31.08
31.12
31.16
30.70
29.79
30.11
31.61
30.49
31.67
31.75
31.62
30.99
31.03

Probes
›city in ft/s
30.88

3D PROBE WORK SHEET

PROJECT:---
Test Run:------
INPUTS

STD. TEMP. DEGREES F (t std)		68				
STD. BAROMETRIC PRESSURE " Hg (Pstd)		29.92				
DUCT SIZE (D)	Traverse	75.000	120.000	75.000	120.000	Flow Element
AVERAGE TEMPERATURE DEGREES F (ts)		695				
AVERAGE PRESSURE IN. W.C. (Pg)		2.16				
ACTUAL BAROMETRIC PRESSURE " Hg (Pbar)		25.50				
% O2 (20.95)		20.95				
% N2 (78.09)		78.09				
% CO2 (0.03)		0.03				
% CO (0.0)		0.00				
%A (0.93)		0.93				
% H2O (0.0)		0.00				

CALCULATIONS

	Traverse	Flow Elem.	% Difference
DRY MOLE FRACTION OF STACK (Mfd) =	1.000	1.000	
STACK PRESSURE " Hg (Ps) =	25.66	25.66	
DRY MOLECULAR WT. OF STACK GAS Lb / Lb -Mole(Md)=	28.966	28.966	
WET MOLECULAR WT. OF STACK GAS Lb / Lb -Mole (Ms)=	28.966	28.966	
STACK AREA SQ. FT (As) =	62.500	62.500	
STACK VELOCITY FT/ SEC. (Vs) =	45.61	41.43	
ACTUAL STACK VOLUME (Q acfm) =	171,022	155,374	-9.15
DRY STANDARD VOLUMETRIC STACK FLOW (Q scfmd) =	67,071	60,934	-9.15
WET STANDARD VOLUMETRIC STACK FLOW (Q scfmw) =	67,071	60,934	-9.15
FLOW IN LBS/HR (wet) =	302350	274685	-9.15
FLOW IN LBS/HR (dry) =	302350	274685	-9.15

GAS DENSITY AT ACTUAL CONDITIONS, LBS/CU.FT.(wet)	0.029465
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (wet)	0.075132
GAS DENSITY AT STANDARD CONDITIONS, LBS/CU.FT. (dry)	0.075132

IP7_037118

Port #	Depth#	Probes Vp In. W.C.	Measured Yaw Angle Degrees	Air Temp. °F	P1 - P23 In.W.C.	Pitch Press. P4 - P5 In.W.C.	P1-Patm (Pt) In. W.C.	P23-Patm Ps Choke In w.c.	From Chart P1-Pt/Pt-Ps TP Coeff.	TP Coeff. * Corrected Pv P1-Pt	(P1-Patm) Minus P1-Pt	P23 Corrected In w.c.	Calculated P4-P5/P1-P23 F1	From Chart Pitch Angle Degrees	From Chart Pt-Ps/P1-P23 (F2)^2	Corrected Pv Pt-Ps In.W.C.	Resultant Angle Degrees	Traverse Point Velocity
1	1	0.147	-12.00	636.8	0.018	0.000	2.09	2.09	0.000	0.000	2.09	2.09	0.000	-0.501	0.980	0.018	12.01	13.49
	2	0.141	5.00	645.5	0.041	0.012	2.14	2.12	0.000	0.000	2.14	2.12	0.293	19.782	1.015	0.042	20.38	19.94
	3	0.147	8.00	653	0.106	-0.078	1.98	1.88	0.000	0.000	1.98	1.86	-0.736	-4.670	0.989	0.105	9.26	33.45
	4	0.148	5.00	819.3	0.133	-0.023	2.10	1.98	-0.001	0.000	2.10	1.96	-0.173	-12.757	1.012	0.135	13.69	40.00
	5	0.149	2.00	805.3	0.136	-0.026	2.25	2.12	-0.001	0.000	2.25	2.10	-0.191	-13.714	1.014	0.138	13.86	40.23
	6	0.149	0.00	795.3	0.172	0.021	2.19	2.02	0.000	0.000	2.19	1.99	0.122	12.469	0.989	0.170	12.47	44.76
	7	0.150	0.00	778	0.179	0.050	2.11	1.95	0.000	0.000	2.11	1.92	0.279	19.958	1.016	0.182	19.96	44.24
	8	0.149	10.00	678.6	0.199	0.082	2.07	1.87	0.000	0.000	2.07	1.84	0.412	18.639	1.009	0.201	21.07	44.26
	9	0.145	18.00	689.7	0.237	0.090	2.21	1.98	0.000	0.000	2.21	1.94	0.380	18.063	1.006	0.239	25.29	46.97
	10	0.149	5.00	775.8	0.270	0.114	2.40	2.14	0.000	0.000	2.40	2.10	0.422	19.155	1.011	0.273	19.77	54.22
2	1	0.144	-5.00	606.6	0.033	0.009	2.08	2.06	0.000	0.000	2.08	2.06	0.273	20.008	1.016	0.034	20.60	17.56
	2	0.153	-8.00	626.1	0.059	0.017	2.20	2.16	0.000	0.000	2.20	2.15	0.288	19.852	1.015	0.060	21.34	23.56
	3	0.149	-2.00	637.5	0.072	0.025	2.29	2.23	0.000	0.000	2.29	2.22	0.347	18.521	1.008	0.073	18.62	26.52
	4	0.150	8.00	645.8	0.099	0.027	2.44	2.35	0.000	0.000	2.44	2.33	0.273	20.008	1.016	0.101	21.49	30.77
	5	0.150	-6.00	651.8	0.094	0.000	2.14	2.07	0.000	0.000	2.14	2.06	0.000	-0.501	0.980	0.092	6.02	31.56
	6	0.154	0.00	659.7	0.130	0.000	2.14	2.03	0.000	0.000	2.14	2.01	0.000	-0.501	0.980	0.127	0.50	37.45
	7	0.154	7.00	664.5	0.156	0.000	2.21	2.07	0.000	0.000	2.21	2.05	0.000	-0.501	0.980	0.153	7.02	40.81
	8	0.149	5.00	669.4	0.193	0.050	2.26	2.09	0.000	0.000	2.26	2.06	0.259	20.021	1.016	0.196	20.61	43.69
	9	0.151	10.00	672.5	0.273	0.136	2.37	2.11	0.000	0.000	2.37	2.07	0.498	31.113	1.194	0.326	32.53	50.81
	10	0.150	25.00	675.4	0.344	0.095	2.67	2.34	0.000	0.000	2.67	2.28	0.276	19.985	1.016	0.349	31.60	53.19
3	1	0.146	2.00	606.6	0.025	0.000	2.09	2.09	0.000	0.000	2.09	2.09	0.000	-0.501	0.980	0.024	2.06	16.02
	2	0.145	-5.00	683.6	0.044	0.000	2.19	2.17	0.000	0.000	2.19	2.17	0.000	-0.501	0.980	0.043	5.02	21.93
	3	0.146	12.00	740.7	0.079	0.000	2.33	2.28	0.000	0.000	2.33	2.27	0.000	-0.501	0.980	0.077	12.01	29.56
	4	0.146	-4.00	761.9	0.100	0.003	2.12	2.04	0.000	0.000	2.12	2.03	0.030	2.602	0.977	0.098	4.77	34.15
	5	0.149	5.00	772.2	0.102	0.000	2.10	2.02	0.000	0.000	2.10	2.01	0.000	-0.501	0.980	0.100	5.02	34.67
	6	0.148	5.00	771.2	0.121	0.095	2.11	2.01	0.001	0.000	2.11	1.99	0.785	37.058	1.377	0.167	37.35	35.71
	7	0.149	8.00	774.6	0.147	0.000	2.20	2.08	0.000	0.000	2.20	2.06	0.000	-0.501	0.980	0.144	8.02	41.41
	8	0.144	10.00	774	0.217	0.045	2.36	2.17	0.000	0.000	2.36	2.14	0.207	18.799	1.010	0.219	21.21	48.07
	9	0.145	10.00	792	0.296	0.050	2.48	2.22	0.000	0.000	2.48	2.18	0.169	16.531	1.001	0.296	19.25	57.01
	10	0.147	28.00	783.3	0.351	0.131	2.41	2.09	0.000	0.000	2.41	2.03	0.373	18.096	1.007	0.353	32.94	55.17
4	1	0.152	10.00	583.4	0.043	0.000	2.28	2.28	0.000	0.000	2.28	2.28	0.000	-0.501	0.980	0.042	10.01	20.47
	2	0.150	10.00	602.1	0.089	0.000	2.17	2.13	0.000	0.000	2.17	2.12	0.000	-0.501	0.980	0.087	10.01	29.72
	3	0.154	8.00	718.2	0.150	0.000	2.18	2.07	0.000	0.000	2.18	2.05	0.000	-0.501	0.980	0.147	8.02	40.87
	4	0.149	6.00	633.6	0.206	0.000	2.15	1.99	0.000	0.000	2.15	1.96	0.000	-0.501	0.980	0.202	6.02	46.34
	5	0.157	-3.00	722.7	0.188	0.000	2.21	2.06	0.000	0.000	2.21	2.03	0.000	-0.501	0.980	0.184	3.04	46.23
	6	0.153	4.00	761.6	0.199	0.000	2.25	2.10	0.000	0.000	2.25	2.07	0.000	-0.501	0.980	0.195	4.03	48.28
	7	0.152	7.00	662.7	0.227	0.062	2.48	2.29	0.000	0.000	2.48	2.26	0.273	20.005	1.016	0.231	21.15	47.06
	8	0.153	7.00	666.7	0.301	0.079	2.59	2.33	0.000	0.000	2.59	2.29	0.262	20.030	1.016	0.306	21.17	54.27
	9	0.151	2.00	673.3	0.364	0.157	2.46	2.14	0.000	0.000	2.46	2.08	0.431	19.790	1.015	0.369	19.89	60.34
	10	0.156	23.00	675.7	0.347	0.068	2.58	2.28	0.000	0.000	2.58	2.23	0.196	18.243	1.007	0.349	29.04	54.61
5	1	0.158	5.00	609.7	0.156	-0.020	2.55	2.44	0.000	0.000	2.55	2.42	-0.128	-10.356	1.006	0.157	11.49	39.80
	2	0.151	2.00	635.4	0.197	0.009	2.52	2.37	0.000	0.000	2.52	2.34	0.046	4.298	0.977	0.192	4.74	45.36
	3	0.160	0.00	646	0.341	0.042	2.60	2.30	0.000	0.000	2.60	2.25	0.123	12.575	0.990	0.337	12.57	59.12
	4	0.155	-2.00	658.7	0.387	0.105	2.59	2.25	0.000	0.000	2.59	2.19	0.271	20.015	1.016	0.393	20.11	61.76
	5	0.156	5.00	692.2	0.368	0.088	2.62	2.29	0.000	0.000	2.62	2.23	0.239	19.799	1.015	0.373	20.40	60.96
	6	0.153	3.00	778.1	0.372	0.107	2.64	2.30	0.000	0.000	2.64	2.24	0.288	19.859	1.015	0.378	20.08	63.68
	7	0.153	10.00	773.3	0.382	0.070	2.80	2.46	0.000	0.000	2.80	2.40	0.183	17.504	1.004	0.384	20.08	64.04
	8	0.155	15.00	767.2	0.387	0.108	2.76	2.41	0.000	0.000	2.76	2.35	0.279	19.960	1.016	0.393	24.78	62.51
	9	0.157	10.00	721.5	0.383	0.131	2.63	2.29	0.000	0.000	2.63	2.23	0.342	18.642	1.009	0.386	21.07	62.52
	10	0.157	8.00	732.2	0.349	0.050	2.71	2.40	0.000	0.000	2.71	2.35	0.143	14.452	0.994	0.347	16.48	61.14
6	1	0.154	-3.00	652.4	0.343	-0.053	2.76	2.46	-0.001	0.000	2.76	2.41	-0.155	-11.792	1.010	0.346	12.16	60.15
	2	0.152	-5.00	660.8	0.331	0.000	2.68	2.40	0.000	0.000	2.68	2.35	0.000	-0.501	0.980	0.324	5.02	59.54
	3	0.157	-3.00	686.3	0.443	-0.030	2.84	2.44	0.000	0.000	2.84	2.37	-0.068	-6.428	0.994	0.440	7.09	69.90
	4	0.158	-5.00	657.3	0.438	0.075	2.78	2.38	0.000	0.000	2.78	2.31	0.171	16.697	1.001	0.439	17.41	66.22
	5	0.158	0.00	677.7	0.351	0.136	2.64	2.33	0.000	0.000	2.64	2.28	0.387	18.079	1.006	0.353	18.08	59.75
	6	0.159	3.00	668.4	0.390	0.099	2.72	2.37	0.000	0.000	2.72	2.31	0.254	19.992	1.016	0.396	20.21	62.21
	7	0.158	0.00	675	0.353	0.083	2.76	2.44	0.000	0.000	2.76	2.38	0.235	19.718	1.014	0.358	19.72	59.49
	8	0.155	2.00	680.4	0.302	0.118	2.64	2.38	0.000	0.000	2.64	2.34	0.391	18.106	1.007	0.304	18.21	55.45
	9	0.152	5.00	677.9	0.329	0.059	2.67	2.38	0.000	0.000	2.67	2.33	0.179	17.253	1.003	0.330	17.94	57.80
	10	0.152		678.9	0.313	0.040	2.56	2.29										

Avg. Duct Static = 2.16

	Average Temp.
Yaw Avg. = 4.58	695
Std. Dev. = 7.63	

		Traverse Avg. Velo
Pitch Avg. = 10.47	Result Angle Avg. = 15.86	45.61
Std. Dev. = 11.74	Std. Dev. = 8.39	

IP7_037119

Probes Point Velocity
39.82
39.15
40.13
43.16
43.06
42.90
42.75
40.86
40.50
42.56
38.87
40.42
40.10
40.38
40.50
41.19
41.27
40.68
41.01
40.92
39.14
40.38
41.51
41.89
42.50
42.34
42.54
41.80
42.25
42.40
39.48
39.58
42.25
40.04
42.74
42.88
40.96
41.16
41.03
41.74
40.75
40.32
41.71
41.29
42.04
43.15
43.06
43.24
42.70
42.89
41.03
40.92
42.06
41.66
42.04
41.99
41.98
41.68
41.23

Probes
›city in ft/s
41.43

AIR MONITOR CORPORATION

K-FACTOR FLOW WORKSHEET

PROJECT: **InterMountatin Power OFA**
WORK ORDER: **50600** *REV:*
TAG(S): **U2 SE**

Station: VOLU-probe/SS w/Temp Probe
Transmitter Model: CAMM
Traverse Probe Type: C-4526 14'
Test Technician: Dan Beistel

Given:

Point #	*% Flow*	*Measured*	*Reference*
Low	50	140,854	196,333
Mid	71	239,979	264,502
*High**	100	297,671	312,051

Transmitter Full Scale (Calibrated): 387,000
Units of Meas.: lbs.hr.

*3-pt. K-Factors only. (Not used in 2-pt. Ks)

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain and Bias applied prior to square root)

Point	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Correceted Flow*	*Eng. Units*	*% Error*
Low	140,854	196,333	lbs.hr.	-28.26	195,719	lbs.hr.	-0.31
Mid	239,979	264,502	lbs.hr.	-9.27	265,327	lbs.hr.	0.31
High	297,671	312,051	lbs.hr.	-4.61	311,075	lbs.hr.	-0.31

Uncorrected Full Scale = 387,000 lbs.hr. Gain = 0.850
Corrected Full Scale (using original max DP) = 385,697 lbs.hr. % Bias = 14.31

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

				(Gain 1) 1.515		*(Gain 2)* 1.155		*(Gain 3)* 1.432	
Point	*Measured*	*Reference*	*% Error*	*M1*	*% Error*	*M2*	*% Error*	*M3*	*% Error*
Low	140,854	196,333	-28.3	173,390	-11.7	151,358	-22.9	168,552	-14.1
Mid	239,979	264,502	-9.3	295,411	11.7	257,875	-2.5	287,169	8.6
High	297,671	312,051	-4.6	366,430	17.4	319,869	2.5	356,206	14.1

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng. Units*	*% Error*
1	140,854	196,333	lbs.hr.	-28.26	196,333	lbs.hr.	0.00
2	239,979	264,502	lbs.hr.	-9.27	264,501	lbs.hr.	0.00

Uncorrected Full Scale = 387,000 lbs.hr. Gain = 0.832
Corrected Full Scale (using original max DP) = 382,975 lbs.hr. % Bias = 14.71

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng. Units*	*% Error*
1	140,854	196,333	lbs.hr.	-28.26	173,390	lbs.hr.	-11.69
2	239,979	264,502	lbs.hr.	-9.27	295,411	lbs.hr.	11.69

Uncorrected Full Scale = 387,000 lbs.hr. Gain = 1.515
Corrected Full Scale (using original max DP) = 476,392 lbs.hr.

AIR MONITOR CORPORATION

K-FACTOR FLOW WORKSHEET

PROJECT: **InterMountatin Power OFA**
WORK ORDER: **50600** *REV:*
TAG(S): **U2 NE**

Station: VOLU-probe/SS w/Temp Probe
Transmitter Model: CAMM
Traverse Probe Type: C-4526 14'
Test Technician: Dan Beistel

Given:

Point #	*% Flow*	*Measured*	*Reference*
Low	50	154,621	188,634
Mid	71	233,740	253,399
*High**	100	270,385	280,225

Transmitter Full Scale (Calibrated): 387,000
Units of Meas.: lbs.hr.

*3-pt. K-Factors only. (Not used in 2-pt. Ks)

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain and Bias applied prior to square root)

Point	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Correceted Flow*	*Eng. Units*	*% Error*
Low	154,621	188,634	lbs.hr.	-18.03	189,976	lbs.hr.	0.71
Mid	233,740	253,399	lbs.hr.	-7.76	251,582	lbs.hr.	-0.72
High	270,385	280,225	lbs.hr.	-3.51	282,220	lbs.hr.	0.71

Uncorrected Full Scale = 387,000 lbs.hr. Gain = 0.885
Corrected Full Scale (using original max DP) = 384,079 lbs.hr. % Bias = 9.97

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

				(Gain 1) 1.318		*(Gain 2)* 1.123		*(Gain 3)* 1.256	
Point	*Measured*	*Reference*	*% Error*	*M1*	*% Error*	*M2*	*% Error*	*M3*	*% Error*
Low	154,621	188,634	-18.0	177,510	-5.9	163,855	-13.1	173,287	-8.1
Mid	233,740	253,399	-7.8	268,341	5.9	247,697	-2.2	261,956	3.4
High	270,385	280,225	-3.5	310,410	10.8	286,530	2.2	303,024	8.1

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng.Units*	*% Error*
1	154,621	188,634	lbs.hr.	-18.03	188,634	lbs.hr.	0.00
2	233,740	253,399	lbs.hr.	-7.76	253,399	lbs.hr.	0.00

Uncorrected Full Scale = 387,000 lbs.hr. Gain = 0.932
Corrected Full Scale (using original max DP) = 390,959 lbs.hr. % Bias = 8.89

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng.Units*	*% Error*
1	154,621	188,634	lbs.hr.	-18.03	177,510	lbs.hr.	-5.90
2	233,740	253,399	lbs.hr.	-7.76	268,341	lbs.hr.	5.90

Uncorrected Full Scale = 387,000 lbs.hr. Gain = 1.318
Corrected Full Scale (using original max DP) = 444,289 lbs.hr.

AIR MONITOR CORPORATION

K-FACTOR FLOW WORKSHEET

PROJECT: InterMountatin Power OFA

WORK ORDER: 50600 *REV:*

TAG(S): U2 NW

Station: VOLU-probe/SS w/Temp Probe
Transmitter Model: CAMM
Traverse Probe Type: C-4526 14'
Test Technician: Dan Beistel

Given:

Point #	*% Flow*	*Measured*	*Reference*
Low	50	142,044	172,207
Mid	71	211,475	223,611
*High**	100	245,158	249,820

Transmitter Full Scale (Calibrated): 387,000

Units of Meas.: lbs.hr.

*3-pt. K-Factors only. (Not used in 2-pt. Ks)

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain and Bias applied prior to square root)

Point	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng. Units*	*% Error*
Low	142,044	172,207	lbs.hr.	-17.52	172,388	lbs.hr.	0.11
Mid	211,475	223,611	lbs.hr.	-5.43	223,375	lbs.hr.	-0.11
High	245,158	249,820	lbs.hr.	-1.87	250,082	lbs.hr.	0.11

Uncorrected Full Scale = 387,000 lbs.hr.
Corrected Full Scale (using original max DP) = 369,130 lbs.hr.

Gain = 0.822
% Bias = 8.77

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

				(Gain 1) 1.276		*(Gain 2)* 1.077		*(Gain 3)* 1.226	
Point	*Measured*	*Reference*	*% Error*	*M1*	*% Error*	*M2*	*% Error*	*M3*	*% Error*
Low	142,044	172,207	-17.5	160,450	-6.8	147,420	-14.4	157,286	-8.7
Mid	211,475	223,611	-5.4	238,877	6.8	219,478	-1.8	234,167	4.7
High	245,158	249,820	-1.9	276,925	10.8	254,436	1.8	271,465	8.7

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng. Units*	*% Error*
1	142,044	172,207	lbs.hr.	-17.52	172,207	lbs.hr.	0.00
2	211,475	223,611	lbs.hr.	-5.43	223,610	lbs.hr.	0.00

Uncorrected Full Scale = 387,000 lbs.hr.
Corrected Full Scale (using original max DP) = 370,242 lbs.hr.

Gain = 0.829
% Bias = 8.63

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng. Units*	*% Error*
1	142,044	172,207	lbs.hr.	-17.52	160,450	lbs.hr.	-6.83
2	211,475	223,611	lbs.hr.	-5.43	238,877	lbs.hr.	6.83

Uncorrected Full Scale = 387,000 lbs.hr.
Corrected Full Scale (using original max DP) = 437,146 lbs.hr.

Gain = 1.276

AIR MONITOR CORPORATION

K-FACTOR FLOW WORKSHEET

PROJECT: **InterMountatin Power OFA**
WORK ORDER: **50600** *REV:*
TAG(S): **U2 SW**

Station: VOLU-probe/SS w/Temp Probe
Transmitter Model: CAMM
Traverse Probe Type: C-4526 14'
Test Technician: Dan Beistel

Given:

Point #	*% Flow*	*Measured*	*Reference*
Low	50	125,022	186,222
Mid	71	212,016	250,536
*High**	100	274,685	302,350

Transmitter Full Scale (Calibrated): 387,000
Units of Meas.: lbs.hr.

*3-pt. K-Factors only. (Not used in 2-pt. Ks)

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain and Bias applied prior to square root)

Point	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Correceted Flow*	*Eng. Units*	*% Error*
Low	125,022	186,222	lbs.hr.	-32.86	186,431	lbs.hr.	0.11
Mid	212,016	250,536	lbs.hr.	-15.38	250,255	lbs.hr.	-0.11
High	274,685	302,350	lbs.hr.	-9.15	302,690	lbs.hr.	0.11

Uncorrected Full Scale = 387,000 lbs.hr.
Corrected Full Scale (using original max DP) = 402,821 lbs.hr.
Gain = 0.951
% Bias = 13.29

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

				(Gain 1)		*(Gain 2)*		*(Gain 3)*	
				1.737		1.299		1.603	
Point	*Measured*	*Reference*	*% Error*	*M1*	*% Error*	*M2*	*% Error*	*M3*	*% Error*
Low	125,022	186,222	-32.9	164,762	-11.5	142,496	-23.5	158,270	-15.0
Mid	212,016	250,536	-15.4	279,408	11.5	241,648	-3.5	268,398	7.1
High	274,685	302,350	-9.2	361,997	19.7	313,076	3.5	347,733	15.0

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng.Units*	*% Error*
1	125,022	186,222	lbs.hr.	-32.86	186,222	lbs.hr.	0.00
2	212,016	250,536	lbs.hr.	-15.38	250,537	lbs.hr.	0.00

Uncorrected Full Scale = 387,000 lbs.hr.
Corrected Full Scale (using original max DP) = 403,966 lbs.hr.
Gain = 0.958
% Bias = 13.16

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng.Units*	*% Error*
1	125,022	186,222	lbs.hr.	-32.86	164,762	lbs.hr.	-11.52
2	212,016	250,536	lbs.hr.	-15.38	279,407	lbs.hr.	11.52

Uncorrected Full Scale = 387,000 lbs.hr.
Corrected Full Scale (using original max DP) = 510,011 lbs.hr.
Gain = 1.737

U2 OFA Flows								
Jerry Finlinson 24may04								
	SE	SE	SW	SW	NE	NE	NW	NW
Dampers	DP	Flow	DP	Flow	DP	Flow	DP	Flow
	in w.c.	klb/hr	in w.c.	klb/hr	in w.c.	klb/hr	in w.c.	klb/hr
closed	0.0079	157	0.0082	154	0.0183	153	0.0199	147
1/3 open	0.039	196	0.03	186	0.04	188	0.037	172
2/3 open	0.13	264	0.087	212	0.109	253	0.088	223
both open	0.173	312	0.151	275	0.145	280	0.119	249
Magnehelic	SE		SW		NE		NW	
Closed - E	0		1.75		1.9		0.06	
	0		0.05		0.05		0.04	
	0.05		0.02		0.04		0	
- W	1.75		0.05		0.01		0.01	
Magnehelic								
1/3 open								
Magnehelic								
2/3 open								
Magnehelic								
Both open								

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: Revere controls
WORK ORDER: ______ *REV:* ______
TAG(S): ______

Given Information:

Fluid:	AIR		% H_2O (by volume):	0.00	(%)
Standard Temperature (T_{std}):	68	(deg. F)			
Standard Barometric Pressure (P_{std}):	29.921	(in. Hg)			
Air Temperature (T):	250	(deg. F)	Maximum Flow:		
Stack/Duct Pressure (P_g):	0.00	(in. w.c.)		10,000	(SCFM)
Actual Barometric Pressure (P_{bar}):	24.000	(in. Hg)		Wet	(Wet/Dry)
Air Density at Standard Conditions, DRY:	0.07513	(lbs/ft^3)			
Duct Shape:	CIRC		Square Root Extraction? (Yes/No)		
Duct Diameter:	13.500	(in.)		Yes	

Output: 4-20 mADC

Calculations:

Duct Area (A_s):	0.994	(ft^2)
Maximum Actual Velocity:	16,865	(AFPM)
Absolute Stack/Duct Pressure (P_s):	24.000	(in. Hg)
Dry Mole Fraction of Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.04482	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.1058	5.60	1,676	1,000	1,000	4,508	4,508
20	0.4234	7.20	3,353	2,000	2,000	9,016	9,016
30	0.9525	8.80	5,029	3,000	3,000	13,523	13,523
40	1.6937	10.40	6,706	4,000	4,000	18,031	18,031
50	2.6460	12.00	8,382	5,000	5,000	22,539	22,539
60	3.8107	13.60	10,059	6,000	6,000	27,047	27,047
70	5.1864	15.20	11,735	7,000	7,000	31,555	31,555
80	6.7746	16.80	13,412	8,000	8,000	36,062	36,062
90	8.5736	18.40	15,088	9,000	9,000	40,570	40,570
100	10.5841	20.00	16,764	10,000	10,000	45,078	45,078

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 SCFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 SCFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

0	0.0000	4.00	0	0	0	0	0

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: **Intermountain Power**
WORK ORDER: ______ *REV:* ______
TAG(S): ______

Given Information:

Fluid:	**AIR**		% H_2O (by volume):		
Standard Temperature (T_{std}):	**68**	(deg. F)	**0.00**	(%, by volume)	
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)			
Air Temperature (T):	**680**	**(deg. F)**	**Maximum Flow:**		
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)	**387,000**	(lb/hr)	
Actual Barometric Pressure (P_{bar}):	**25.000**	**(in. Hg)**	**Wet**	(Wet/Dry)	
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)			
Duct Shape:	**RECT**		Square Root Extraction? (Yes/No)		
Duct Height:	**75.000**	**(in.)**	**Yes**		
Duct Width:	**120.000**	**(in.)**			
			Output:		
			4-20 mADC		

Calculations:

Duct Area (A_s):	62.500	(ft^2)		
Maximum Actual Velocity:	3,550	(AFPM)		
Absolute Duct Pressure (P_s):	25.000	(in. Hg)		
Dry Mole Fraction of Duct (Mfd):	1.000			
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)	Gain:	1.515
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)	% Bias:	0
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)		
Air Density at Actual Conditions, WET:	0.02907	(lbs/ft^3)	K-Factor:	ON

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.0020	5.60	22,184	8,585	8,585	38,700	38,700
20	0.0080	7.20	44,369	17,170	17,170	77,400	77,400
30	0.0181	8.80	66,553	25,755	25,755	116,100	116,100
40	0.0321	10.40	88,738	34,340	34,340	154,800	154,800
50	0.0502	12.00	110,924	42,926	42,926	193,500	193,500
60	0.0723	13.60	133,109	51,511	51,511	232,200	232,200
70	0.0984	15.20	155,293	60,096	60,096	270,900	270,900
80	0.1285	16.80	177,478	68,681	68,681	309,600	309,600
90	0.1626	18.40	199,662	77,266	77,266	348,300	348,300
100	0.2008	20.00	221,846	85,851	85,851	387,000	387,000

Transmitter:	CAMM	Power (voltage/type):	24VAC
Flow Element:	VOLU-probe/SS w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0-387,000 lbs/hr	Square Root:	ON
Temperature Range:	0 to 700deg.	Density Compensation:	ON
Pressure Comp. Range:	?		

Temperature Sensor: Single-Pt. Type "E" T/C Probe with panel-mounted 4-20mADC temperature transmitter.

Display Line #1:	0-387,000 lbs/hr	(FLOW)
Display Line #2:	0 to 700deg.	(TEMPERATURE)
Display Line #3:	?	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to .7528 IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: ______________________
WORK ORDER: __________ *REV:* __________
TAG(S): ______________________

Given Information:

Fluid:	**AIR**	
Standard Temperature (T_{std}):	**68**	(deg. F)
Standard Barometric Pressure (P_{std}):	**29.921**	(in. Hg)
Air Temperature (T):	**150**	(deg. F)
Stack/Duct Pressure (P_g):	**0.00**	(in. w.c.)
Actual Barometric Pressure (P_{bar}):	**29.921**	(in. Hg)
Air Density at Standard Conditions, DRY:	**0.07513**	(lbs/ft^3)
Duct Shape:	**CIRC**	
Duct Diameter:	**50.897**	(in.)

% H_2O (by volume): **5.00** (%)

Maximum Volumetric Flow: **40,000** (ACFM)

Square Root Extraction? (Yes/No) **Yes**

Output: **4-20 mADC**

Calculations:

Stack/Duct Area (A_s):	14.129	(ft^2)
Maximum Actual Velocity:	2,831	(AFPM)
Absolute Stack/Duct Pressure (P_s):	29.921	(in. Hg)
Dry Mole Fraction of Stack/Duct (Mfd):	0.950	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.417	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07371	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.06380	(lbs/ft^3)

Gain: 3
% Bias: -3
K-Factor: ON

% DP (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0042	4.00	0	0	0	0	0
10	0.0057	5.60	4,000	3,289	3,462	14,826	15,311
20	0.0099	7.20	8,000	6,578	6,924	29,652	30,622
30	0.0170	8.80	12,000	9,868	10,387	44,483	45,937
40	0.0269	10.40	16,000	13,157	13,849	59,309	61,249
50	0.0396	12.00	20,000	16,446	17,312	74,135	76,564
60	0.0552	13.60	24,000	19,735	20,774	88,961	91,875
70	0.0736	15.20	28,000	23,024	24,236	103,788	107,186
80	0.0948	16.80	32,000	26,313	27,698	118,614	122,497
90	0.1189	18.40	36,000	29,603	31,161	133,444	137,812
100	0.1458	20.00	40,000	32,892	34,623	148,271	153,123

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 ACFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 ACFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

AIR MONITOR CORPORATION

TRANSMITTER SPAN/MASS FLOW CALCULATIONS

PROJECT: ____________________

WORK ORDER: __________ *REV:* __________

TAG(S): ____________________

Given Information:

Fluid:	AIR		% H_2O (by volume):	0.00	(%)
Standard Temperature (T_{std}):	68	(deg. F)			
Standard Barometric Pressure (P_{std}):	29.921	(in. Hg)			
Air Temperature (T):	165	(deg. F)	Maximum Differential Pressure:	0.6700	(inches w.c.)
Stack/Duct Pressure (P_g):	0.00	(in. w.c.)			
Actual Barometric Pressure (P_{bar}):	24.000	(in. Hg)			
Air Density at Standard Conditions, DRY:	0.07513	(lbs/ft^3)	Square Root Extraction? (Yes/No)	Yes	
Duct Shape:	CIRC				
Duct Diameter:	13.500	(in.)	Output (4-20,0-10,0-5):	4-20 mADC	

Calculations:

Stack/Duct Area (A_s):	0.994	(ft^2)
Maximum Actual Velocity:	3,981	(AFPM)
Absolute Stack/Duct Pressure (P_s):	24.000	(in. Hg)
Dry Mole Fraction of Stack/Duct (Mfd):	1.000	
Dry Molecular Wt. Of Air (Md):	28.965	(lb/lb-mole)
Wet Molecular Wt. Of Air (Ms):	28.965	(lb/lb-mole)
Air Density at Standard Conditions, WET:	0.07513	(lbs/ft^3)
Air Density at Actual Conditions, WET:	0.05091	(lbs/ft^3)

K-Factor: OFF

% FLOW (%)	Diff. Press. (in. w.c.)	Output (mADC)	Actual Flow (ACFM)	Std.Flow/Dry (SCFM)	Std.Flow/Wet (SCFM)	MassFlow/Dry (Lbs/Hr)	MassFlow/Wet (Lbs/Hr)
0	0.0000	4.00	0	0	0	0	0
10	0.0067	5.60	396	268	268	1,208	1,208
20	0.0268	7.20	791	536	536	2,416	2,416
30	0.0603	8.80	1,187	804	804	3,624	3,624
40	0.1072	10.40	1,583	1,073	1,073	4,837	4,837
50	0.1675	12.00	1,979	1,341	1,341	6,045	6,045
60	0.2412	13.60	2,374	1,609	1,609	7,253	7,253
70	0.3283	15.20	2,770	1,877	1,877	8,461	8,461
80	0.4288	16.80	3,166	2,145	2,145	9,669	9,669
90	0.5427	18.40	3,562	2,413	2,413	10,877	10,877
100	0.6700	20.00	3,957	2,682	2,682	12,090	12,090

Transmitter:	MASS-tron II	Power (voltage/type):	24VAC
Flow Element:	CA Station w/Temp Probe	Power Configuration:	4-Wire
Transmitter Maximum Range:	0 - 40,000 ACFM	Square Root:	ON
Temperature Range:	0 to XXX°F	Density Compensation:	ON
Pressure Comp. Range:	26.00 to 34.00 in. Hg		

Temperature Sensor: (N/A)

Display Line #1:	0 - 40,000 ACFM	(FLOW)
Display Line #2:	0 to XXX°F	(TEMPERATURE)
Display Line #3:	26.00 to 34.00 in. Hg	(ABSOLUTE PRESSURE)
Display Line #4:	0.000 to X.XXX IN w.c.	(DIFFERENTIAL PRESSURE)

Conversions/Calculations

(Inputs are boxed; outputs are yellow.)

Absolute Pressure

Elevation:	4500	ft MSL
Std. Barometer:	25.364	in. Hg
Static Pressure:	0.0	in. w.c.
Absolute Pressure:	25.364	in. Hg

Pressure

Inches H2O:	83
Inches Hg	6.105
PSI:	2.999
PSI:	1
Inches H2O:	27.681
Inches Hg:	2.036

Equivalent Duct Diameter

Height:	26
Width:	12
D:	16.42

Flow

CFM:	35000
m3/hr:	59,465
L/sec:	16,518
lb/hr:	100000
kg/hr:	229,570
T/hr (metric):	45.360

Density

lbs/ft3:	0.07513
kg/m3:	1.203
g/cm3:	0.001203
kg/m3:	1.203
lbs/ft3:	0.07507
g/cm3:	0.001203

Temperature

Deg. F:	32
Deg. C:	0.00
Deg. C:	100.0
Deg. F:	212

Dimensions

Inches:	39.37
Feet:	3.28
Meters:	1.000
Millimeters:	1000
Millimeters:	25.4
Meters:	0.025
Inches:	1.000
Feet:	0.083

AIR MONITOR CORPORATION

K-FACTOR FLOW WORKSHEET

PROJECT: ______

WORK ORDER: ______ *REV:* ______

TAG(S): ______

Station: CA Station w/Temp Probe
Transmitter Model: MASS-tron II
Traverse Probe Type: ______
Test Technician: ______

Given:

Point #	*% Flow*	*Measured*	*Reference*
Low	50	116,570	143,149
Mid	71	179,780	219,878
*High**	100	237,770	286,216

Transmitter Full Scale (Calibrated): 387,000

Engineering Units: KPPH

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING **WITH BIAS**
(K-Factor Gain and Bias applied prior to square root)

Point	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng. Units*	*% Error*
Low	116,570	143,149	KPPH	-18.57	143,941	KPPH	0.55
Mid	179,780	219,878	KPPH	-18.24	218,655	KPPH	-0.56
High	237,770	286,216	KPPH	-16.93	287,799	KPPH	0.55

Uncorrected Full Scale = 387,000 KPPH

Corrected Full Scale, Using Original Max DP = 466,547 KPPH

Gain = 1.44622

% Bias = 0.71236

K-FACTOR - **3 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

				(Gain 1) 1.50190		*(Gain 2)* 1.47214		*(Gain 3)* 1.47807	
Point	*Measured*	*Reference*	*% Error*	*M1*	*% Error*	*M2*	*% Error*	*M3*	*% Error*
Low	116,570	143,149	-18.6	142,859	-0.2	141,437	-1.2	141,721	-1.0
Mid	179,780	219,878	-18.2	220,324	0.2	218,130	-0.8	218,569	-0.6
High	237,770	286,216	-16.9	291,392	1.8	288,491	0.8	289,071	1.0

K-FACTOR - **2 POINTS** - BEST FIT WHERE ERRORS ARE EQUAL IN % OF READING AND **BIAS = 0**
(K-Factor Gain applied prior to square root)

Point #	*Measured*	*Reference*	*Eng. Units*	*% Error*	*Corrected Flow*	*Eng.Units*	*% Error*
1	116,570	143,149	KPPH	-18.57	142,859	KPPH	-0.20
2	179,780	219,878	KPPH	-18.24	220,324	KPPH	0.20

Uncorrected Full Scale = 387,000 KPPH

Corrected Full Scale = 474,276 KPPH
(using max. DP)

Gain = 1.50190

* "High" value not used in 2-pt.correction.

AS FIRED COAL SAMPLE ANALYSES - IPSC FUELS LAB

Lab #	Date	Time	Moist%	Ash%	S%	Btu/lb	Res Mois%	C%	H%	N%
30448	5/1/2002	17:00	7.17	10.50	0.53	11742	2.04	65.96	4.68	1.32
30454	5/2/2002	17:00	7.04	11.77	0.64	11526	1.73	64.65	4.57	1.31
30460	5/3/2002	17:15	5.46	14.65	0.72	11452	1.44	64.15	4.57	1.37
30463	5/4/2002	17:00	5.46	11.45	0.64	11909	1.68	66.44	4.73	1.38
30466	5/5/2002	17:00	5.39	10.91	0.65	12057	1.40	67.41	4.83	1.45
30477	5/6/2002	17:15	6.16	9.38	0.59	12187	1.41	67.87	4.89	1.38
30481	5/7/2002	17:00	6.06	10.18	0.63	12007	1.37	67.18	4.77	1.37
30487	5/8/2002	17:00	7.44	9.72	0.52	11879	1.77	66.18	4.83	1.29
30492	5/9/2002	17:00	6.76	11.49	0.58	11673	1.51	65.71	4.48	1.34
30496	5/10/2002	17:00	6.29	11.97	0.63	11720	1.81	65.38	4.62	1.39
30499	5/11/2002	17:00	7.16	10.86	0.65	11762	1.68	65.55	4.60	1.38
30501	5/12/2002	17:00	7.25	11.61	0.60	11618	1.55	64.84	4.56	1.35
30507	5/13/2002	17:00	7.87	11.53	0.53	11442	2.18	63.90	4.47	1.25
30510	5/14/2002	17:00	6.24	11.54	0.55	11682	1.79	65.77	4.66	1.32
30515	5/15/2002	17:00	7.34	11.38	0.58	11584	1.76	64.55	4.51	1.33
30518	5/16/2002	17:00	6.32	10.68	0.64	11927	1.78	66.61	4.69	1.39
30523	5/17/2002	17:00	5.59	10.16	0.70	12165	1.35	67.67	4.80	1.44
30527	5/18/2002	17:00	6.64	11.38	0.62	11699	1.43	65.45	4.66	1.34
30530	5/19/2002	17:00	6.82	11.18	0.48	11545	1.67	64.82	4.54	1.30
30539	5/20/2002	17:00	6.86	11.57	0.51	11486	2.21	64.73	4.54	1.29
30543	5/21/2002	17:00	6.69	11.49	0.60	11645	1.99	65.39	4.62	1.37
30549	5/22/2002	17:00	7.28	10.76	0.60	11791	1.63	65.76	4.60	1.41
30557	5/23/2002	17:00	7.04	11.18	0.59	11745	1.76	65.72	4.69	1.39
30562	5/24/2002	17:00	5.36	12.74	0.62	11842	1.36	65.80	4.64	1.47
30566	5/25/2002	17:00	6.66	10.24	0.62	11950	1.50	66.46	4.62	1.40
30568	5/26/2002	17:00	7.30	11.14	0.61	11614	1.70	65.19	4.66	1.32
30569	5/27/2002	17:00	6.51	11.40	0.63	11710	1.43	65.71	4.71	1.34
30574	5/28/2002	17:00	5.98	10.85	0.69	12017	1.33	66.66	4.64	1.40
30581	5/29/2002	17:00	5.35	10.11	0.71	12301	1.85	68.10	4.86	1.47
30585	5/30/2002	17:00	6.66	10.24	0.63	11816	2.15	66.19	4.59	1.36
30592	5/31/2002	17:00	4.74	10.02	0.61	12425	1.39	68.89	4.86	1.51

AS FIRED COAL SAMPLE ANALYSES - IPSC FUELS LAB

Lab #	Date	O%
30448	5/1/2002	9.84
30454	5/2/2002	10.02
30460	5/3/2002	9.08
30463	5/4/2002	9.90
30466	5/5/2002	9.36
30477	5/6/2002	9.73
30481	5/7/2002	9.81
30487	5/8/2002	10.02
30492	5/9/2002	9.64
30496	5/10/2002	9.72
30499	5/11/2002	9.80
30501	5/12/2002	9.79
30507	5/13/2002	10.45
30510	5/14/2002	9.92
30515	5/15/2002	10.31
30518	5/16/2002	9.67
30523	5/17/2002	9.64
30527	5/18/2002	9.91
30530	5/19/2002	10.86
30539	5/20/2002	10.50
30543	5/21/2002	9.84
30549	5/22/2002	9.59
30557	5/23/2002	9.39
30562	5/24/2002	9.37
30566	5/25/2002	10.00
30568	5/26/2002	9.78
30569	5/27/2002	9.70
30574	5/28/2002	9.78
30581	5/29/2002	9.40
30585	5/30/2002	10.33
30592	5/31/2002	9.37

AS FIRED COAL SAMPLE ANALYSES - IPSC FUELS LAB

Lab #	Date	Dry Ash%	Dry S%	Dry C%	Dry H%	Dry N%	Dry O%	Dry Btu/lb	MAF BTU
30448	5/1/2002	11.31	0.57	71.05	5.04	1.42	10.60	12649	14262
30454	5/2/2002	12.66	0.69	69.55	4.92	1.41	10.78	12399	14196
30460	5/3/2002	15.50	0.76	67.85	4.83	1.45	9.60	12113	14335
30463	5/4/2002	12.11	0.68	70.28	5.00	1.46	10.47	12597	14333
30466	5/5/2002	11.53	0.69	71.25	5.11	1.53	9.89	12744	14405
30477	5/6/2002	10.00	0.63	72.33	5.21	1.47	10.37	12987	14429
30481	5/7/2002	10.84	0.67	71.51	5.08	1.46	10.44	12782	14335
30487	5/8/2002	10.50	0.56	71.50	5.22	1.39	10.83	12834	14340
30492	5/9/2002	12.32	0.62	70.47	4.80	1.44	10.34	12519	14279
30496	5/10/2002	12.77	0.67	69.77	4.93	1.48	10.37	12507	14338
30499	5/11/2002	11.70	0.70	70.61	4.95	1.49	10.56	12669	14347
30501	5/12/2002	12.52	0.65	69.91	4.92	1.46	10.56	12526	14318
30507	5/13/2002	12.51	0.58	69.36	4.85	1.36	11.34	12419	14196
30510	5/14/2002	12.31	0.59	70.15	4.97	1.41	10.58	12459	14208
30515	5/15/2002	12.28	0.63	69.66	4.87	1.44	11.13	12502	14252
30518	5/16/2002	11.40	0.68	71.10	5.01	1.48	10.32	12732	14370
30523	5/17/2002	10.76	0.74	71.68	5.08	1.53	10.21	12885	14439
30527	5/18/2002	12.19	0.66	70.10	4.99	1.44	10.61	12531	14271
30530	5/19/2002	12.00	0.52	69.56	4.87	1.40	11.65	12390	14079
30539	5/20/2002	12.42	0.55	69.50	4.87	1.39	11.27	12332	14081
30543	5/21/2002	12.31	0.64	70.08	4.95	1.47	10.55	12480	14232
30549	5/22/2002	11.60	0.65	70.92	4.96	1.52	10.34	12717	14386
30557	5/23/2002	12.03	0.63	70.70	5.05	1.50	10.10	12634	14362
30562	5/24/2002	13.46	0.66	69.53	4.90	1.55	9.90	12513	14459
30566	5/25/2002	10.97	0.66	71.20	4.95	1.50	10.71	12803	14380
30568	5/26/2002	12.02	0.66	70.32	5.03	1.42	10.55	12529	14240
30569	5/27/2002	12.19	0.67	70.29	5.04	1.43	10.38	12525	14265
30574	5/28/2002	11.54	0.73	70.90	4.94	1.49	10.40	12781	14449
30581	5/29/2002	10.68	0.75	71.95	5.13	1.55	9.93	12996	14551
30585	5/30/2002	10.97	0.67	70.91	4.92	1.46	11.07	12659	14219
30592	5/31/2002	10.52	0.64	72.32	5.10	1.59	9.84	13043	14576

May-02 coal sampled May 2002

Weighted Totals

Mine	sampled Total Tonnage	% of Total	% Na2O	HGI	Softening Temp	HHVC Btu/lb	% H20	% Ash	% Volatile
Genwall Resources	56,497.94	11.91	1.84	42.9	2116	12,852	5.96	7.28	37.99
Skyline (Product B) trucks	0.00	0.00	0.97	43.7	2137	12,562	5.51	6.51	43.20
SUFCO (Product A)	195,769.55	41.28	2.20	43.9	2246	11,108	8.55	12.49	33.20
SUFCO	0.00	0.00	0.58	42.8	2394	11,860	5.93	8.95	33.87
Andalex	36,673.43	7.73	0.63	43.2	2355	12,020	5.38	10.04	34.86
West Ridge Resources	28,480.55	6.00	0.93	45.9	2195	13,010	5.18	7.70	35.00
Oxbow Contract	0.00	0.00	2.50	42.6	2234	12,025	4.87	14.03	32.86
Arch-Dugout	0.00	0.00	0.53	40.5	2450	11370	5.93	14.85	32.84
Arch-Dugout (product B)	55,714.60	11.75	0.56	41.5	2425	11915	5.32	12.22	33.41
Arch (spot)	101,158.01	21.33	1.01	41.7	2334	11550	6.84	12.16	33.62
Totals	474,294.08	100.00	1.51	43.10	2275.7	11,690	7.05	11.29	34.12

% Fixed Carbon	% Sulfur
48.77	0.72
44.78	0.40
45.76	0.50
47.51	0.39
49.72	0.46
52.12	1.15
48.24	0.69
46.38	0.71
49.05	0.68
47.38	0.61
47.54	0.61

Boiler Thermal Impact Study of the Upgraded IGS Unit 1&2 Steam Generators

4 February 2003

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Presentation Outline

- Introduction
- Baseline Model Calibration
- Case Studies
- Conclusions

IP7_037144

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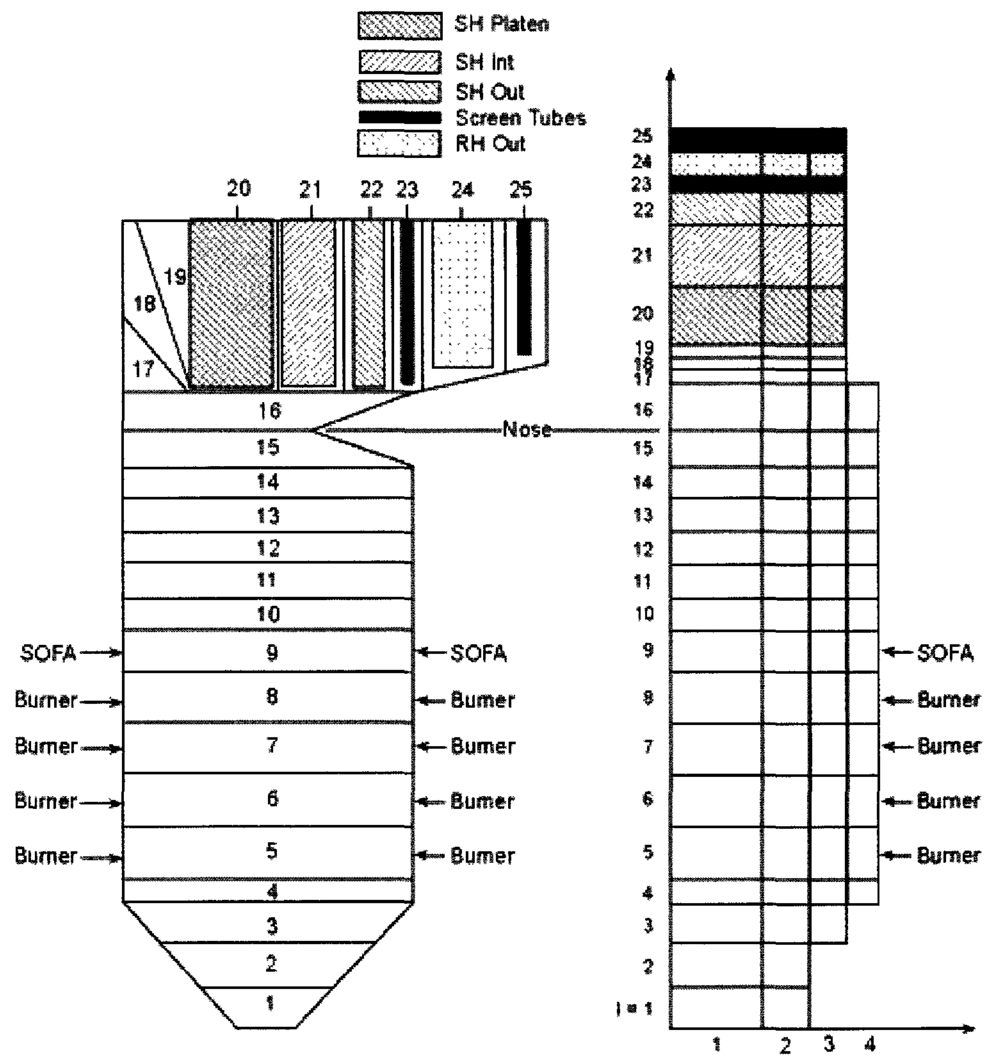
Introduction

- **Primary objectives of the thermal impact study**
  - Determine the impact of additional platen surface area on boiler thermal performance
  - Evaluate the impact of overfire air on boiler performance with and without the platen upgrade
  - Evaluate the impact of fuel type/composition on boiler thermal performance
  - Estimate the tube metal temperatures for OFA operating conditions
- **Develop a boiler thermal model to address these objectives**

Thermal Model Overview

- **Radiation Model:**
  - Semi-stochastic method
  - Four-weighted gray gases
  - H_2O, CO_2, soot, ash, char
- **Burnout of Coal Volatiles**
- **Char Oxidation**
- **Total Heat Balance for Volume and Surface Zones:**
  - Prescription of mean mass fluxes
  - Superposition of turbulence
  - Heat release and gas composition from combustion model
  - Prescription of wall deposit patterns
- **Radiant Heat Exchangers Included**
- **Coupled to boiler cycle code**



a) Furnace division into layers

b) Corresponding model configuration

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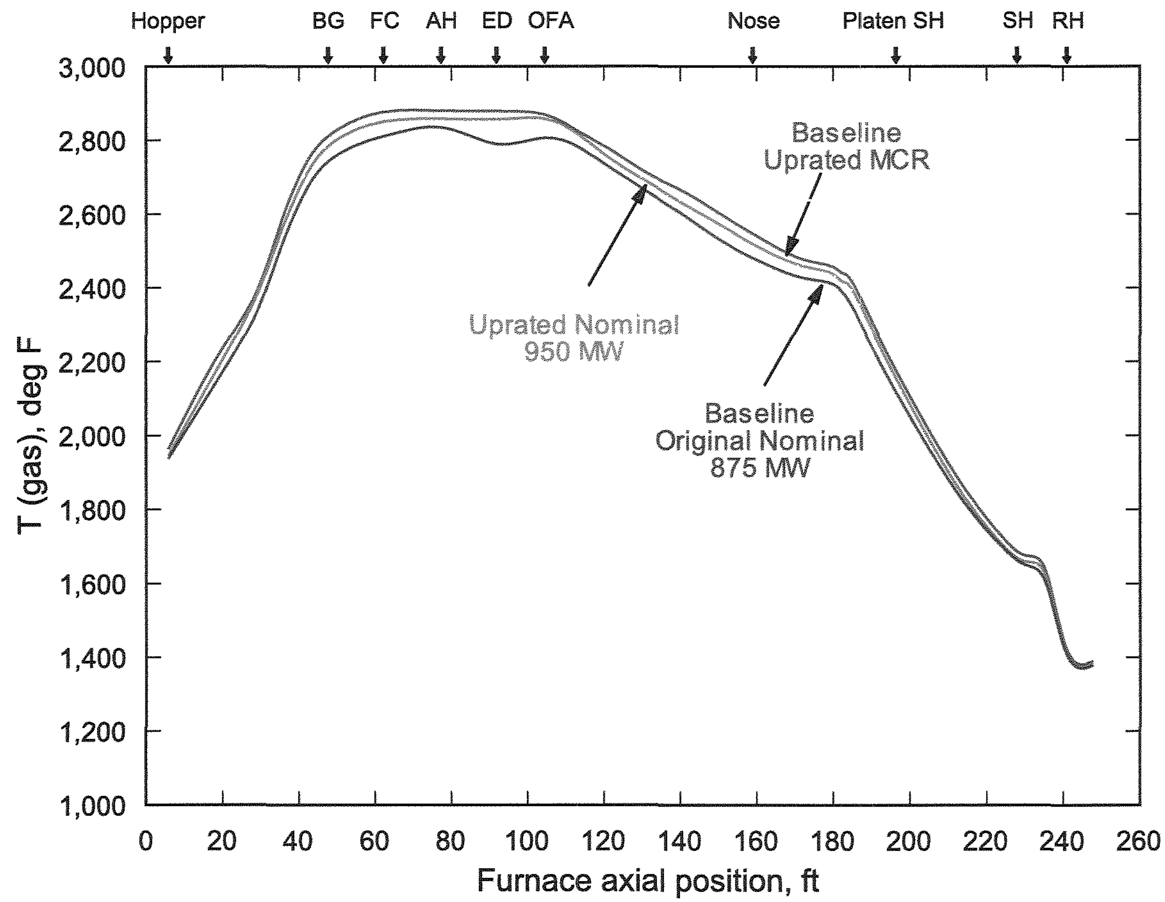
Case Study Matrix

Case Type	Load	Additional Platen Surface Area	Fuel Type	OFA % Total Air	% $O_{2,wet}$
Baseline Calibration	Uprated MCR and 875 MW	No	Fuel A	0	2.5, 3.3
OFA without Platen SH Upgrade	Uprated Nominal (950 MW)	No	Fuel A	0, 5, 10, 15	2.5, 2.95
OFA with Platen SH Upgrade	Uprated Nominal	Yes	Fuel A	0, 10	2.5
Increased Excess Air	Uprated Nominal	Yes	Fuel A	0	2.5, 3.0
Reduced Load	75% and 50% Uprated Nominal	Yes	Fuel A	0	4.75, 7.0
Different Fuels	Uprated Nominal	Yes	Fuels A - E	0, 10 (Fuel E)	2.5

IP7_037147

Boiler Model Calibration

- **Use field data provided by IPSC**
  - Unit 2
  - Data at uprated MCR conditions
  - Coal fineness screen data
- **Calibration parameters**
  - Fuel reactivity
  - Wall fouling distribution
- **Comparison with Unit 1 875 MW data (from IPSC)**
- **Adjust baseline to uprated nominal conditions (950 MW) for study**



Boiler Model Calibration

	Uprated MCR Unit 2 Data Set 16-May-02	Uprated MCR (2dht)	Original Nominal 875 MW Unit 1 Data Set 7-Dec-02	Original Nominal 875 MW
Flue Gas O_2 (% wet)	2.35	2.35	3.30	3.30
Fuel Flow Rate (1000 lb/hr)	734	704		651
Flue gas Temperature (°F) Leaving				
FEGT	2,217	2,378	2,159	2,350
Economizer	736	736	764	757
Air Preheater Out		319		317
Flow Rates (1000 lb/hr)				
Main Steam	6,928	6,916	6,426	6,445
Reheat Steam	5,719	5,695	5,249	5,265
Attemperation flow (1000 lb/hr)				
Superheater	21	17	42	26
Reheater	0	0	1	0
Flue gas split in Backpass (%)				
Pri RH	36.20	43.50	32.81	39.84
Pri SH / Econ	63.80	56.49	67.19	60.16
Water/Steam Temperatures (°F)				
SH Out	999	999	1,001	1,001
RH Out	1004	1,006	1,005	1,005
Percent Carbon in ash	0.556	0.554		0.199
ASME Heat Loss Efficiency (%)	89.15	88.96		88.05

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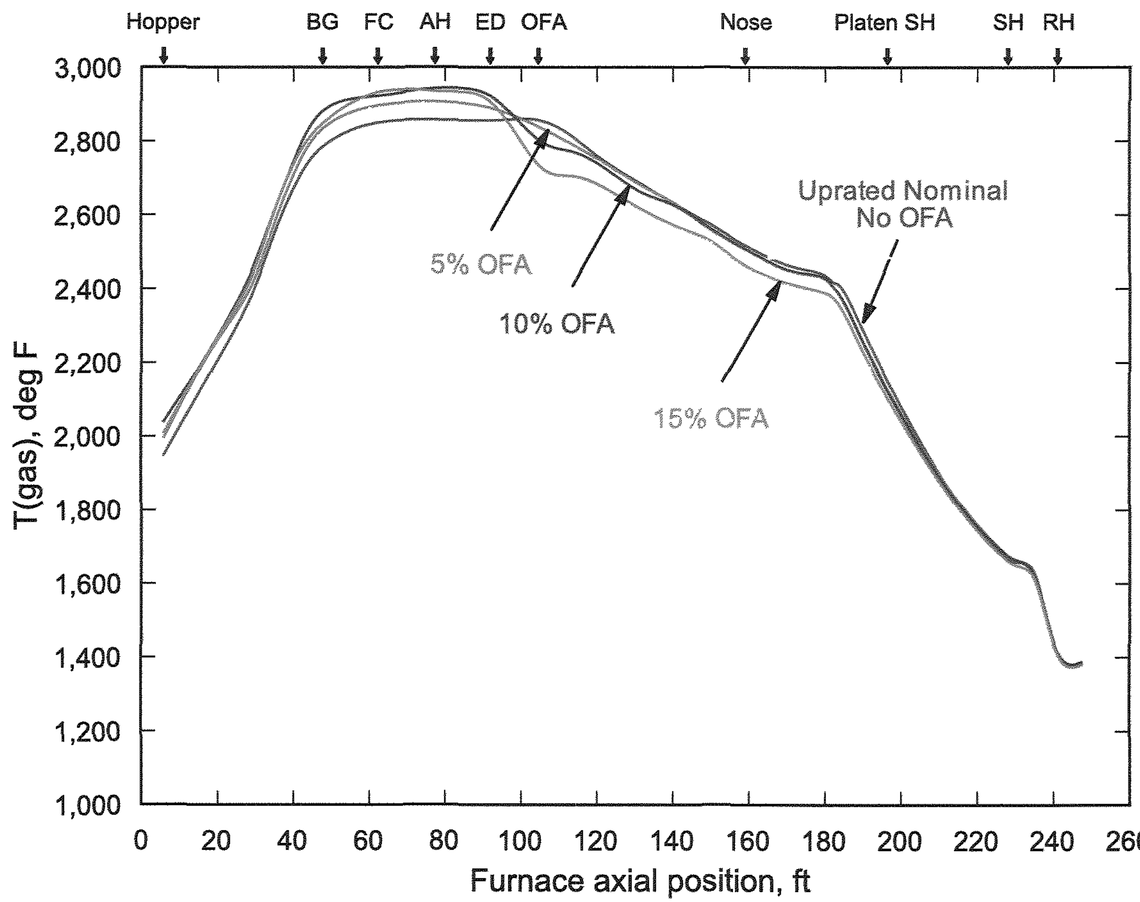
Heat Duties (Boiler Model Calibration)

	Uprated MCR Unit 2 Data Set 16-May-02	Uprated MCR (2dht)	Original Nominal 875 MW Unit 1 Data Set 7-Dec-02	Original Nominal 875 MW
Flow Rates (1000 lb/hr)				
Main Steam	6,928	6,916	6,426	6,445
Reheat Steam	5,719	5,695	5,249	5,265
Attemperation flow (1000 lb/hr)				
Superheater	21	17	42	26
Reheater	0	0	1	0
Water/Steam Temperatures (°F)				
SH Out	999	999	1,001	1,001
RH Out	1004	1,006	1,005	1,005
Percent Carbon in ash	0.556	0.554		0.199
Heat Absorption (kW)				
Economizer	83,582	82,795	69,283	83,344
Waterwall	987,349	986,672	910,602	901,625
Primary SH	254,718	255,529	248,610	241,174
Platen SH	162,339	161,007	143,498	150,734
SH Int	250,934	249,171	205,935	232,347
SH Out	123,585	124,236	152,835	118,242
Pri RH	181,740	181,887	157,188	163,294
RH Out	172,800	172,823	168,278	161,958
Total Heat Absorption (kW)	2,217,047	2,214,120	2,056,229	2,052,718
ASME Heat Loss Efficiency (%)	89.15	88.96		88.05

OFA with No Additional Platen Surface Area

- **OFA operation**
  - Uprated nominal conditions (950 MW)
  - No additional platen area
  - 5 percent OFA
    - 2.5 $\%O_{2,wet}$
    - $SR_b = 1.09$
  - 10 percent OFA
    - 2.5 $\%O_{2,wet}$
    - $SR_b = 1.03$
  - 15 percent OFA
    - 2.95 $\%O_{2,wet}$
    - $SR_b = 1.00$



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OFA with No Additional Platen Surface Area

	Uprated Nominal Baseline 950 MW	Uprated Nominal 5% OFA	Uprated Nominal 10% OFA	Uprated Nominal 15% OFA 15% cleaner PSH
Flue Gas O_2 (% wet)	2.50	2.50	2.50	2.95
Fuel Flow Rate (1000 lb/hr)	679	679	679	679
Flue gas Temperature (^oF) Leaving				
FEGT	2,374	2,362	2,362	2,302
Economizer	735	741	736	741
Air Preheater Out	317	318	318	317
Flow Rates (1000 lb/hr)				
Main Steam	6,664	6,661	6,656	6,659
Reheat Steam	5,501	5,499	5,494	5,497
Attemperation flow (1000 lb/hr)				
Superheater	26	16	3	1
Reheater	0	0	0	0
Normalized waterwall conductance*	1.000	0.936	0.897	0.949
Flue gas split in Backpass (%)				
Pri RH	43.95	42.91	43.95	41.41
Pri SH / Econ	56.05	57.09	56.05	58.59
Water/Steam Temperatures (^oF)				
SH Out	999	999	999	999
RH Out	1,005	1,004	1,005	1,006
Percent Carbon in ash	0.446	0.571	0.992	1.300
ASME Heat Loss Efficiency (%)	88.98	88.95	88.90	88.73

* Conductance normalized with that at uprated nominal conditions (950 MW)

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Boiler Thermal Performance Trends with OFA

- **Gas temperature trends with increasing OFA**
  - Increase in burner region
  - Decrease above OFA injectors
- **Attemperation is reduced with increasing OFA (when burner SR > 1.0)**
  - Net loss in superheater heat absorption due to higher waterwall heat absorption and steam generation rates
  - Steam temperature can be maintained by increased waterwall fouling (e.g., fouling increased by 10% at 10% OFA)
- **Carbon in ash increases with increasing OFA**
  - Less oxygen in burner region reduces carbon burnout
  - At 15% OFA, the carbon in ash is 1.3% (SR_b = 1.0)
- **No significant changes in heat duties**

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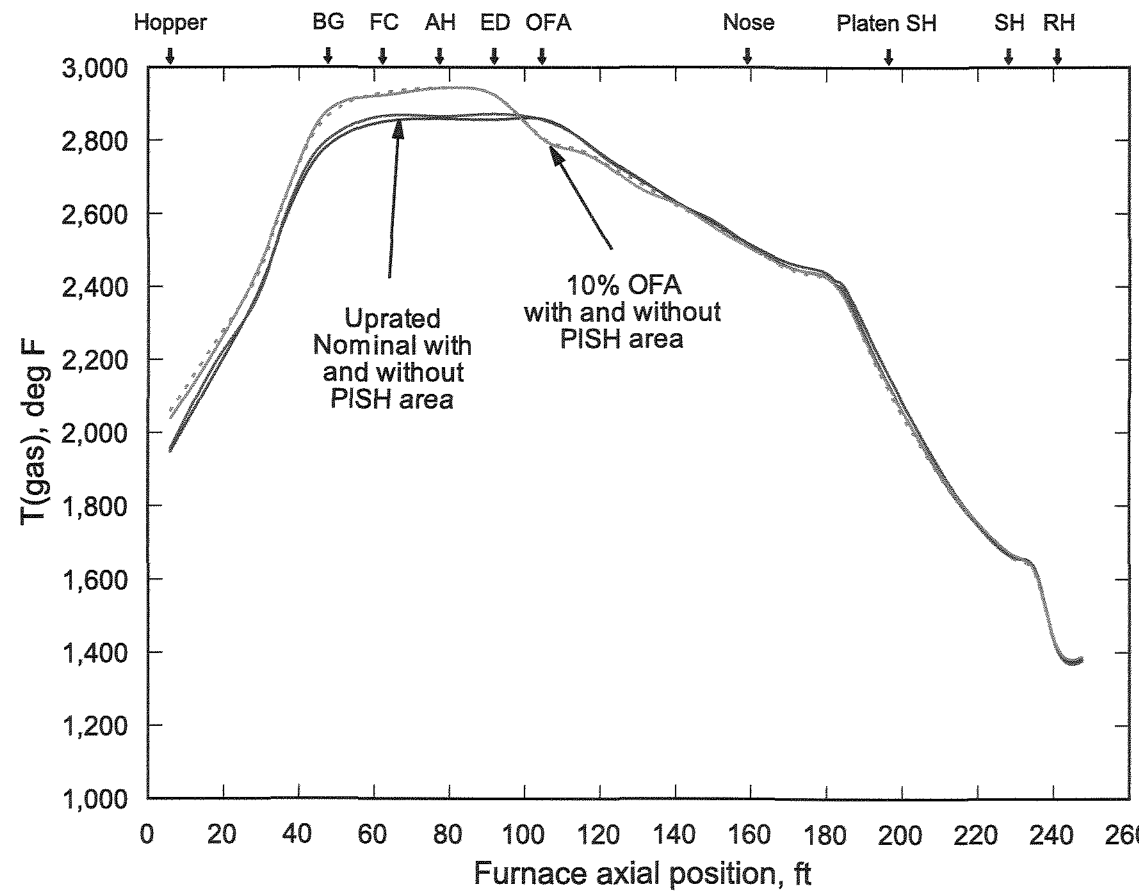
OFA with Additional Platen Surface Area

- **Uprated Nominal Conditions**
  - Additional platen surface area
  - Baseline and 10% OFA conditions
- **10 percent OFA**
  - 2.5 $\%O_{2,wet}$
  - $SR_b = 1.03$
- **Adding platen area has very little effect on gas temperature distribution**
  - Similar results found with CFD cases



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OFA with Additional Platen Surface Area

	Uprated Nominal Baseline 950 MW	Uprated Nominal 10% OFA	Uprated Nominal Baseline 950 MW With Pl SH	Uprated Nominal 10% OFA With Pl SH
Flue Gas O_2 (% wet)	2.50	2.50	2.50	2.50
Fuel Flow Rate (1000 lb/hr)	679	679	679	679
Flue gas Temperature (°F) Leaving				
FEGT	2,374	2,362	2,375	2,348
Economizer	735	736	728	738
Air Preheater Out	317	318	318	317
Flow Rates (1000 lb/hr)				
Main Steam	6,664	6,656	6,636	6,628
Reheat Steam	5,501	5,494	5,478	5,471
Attemperation flow (1000 lb/hr)				
Superheater	26	3	26	27
Reheater	0	0	0	0
Normalized waterwall conductance*	1.000	0.897	0.967	0.900
Flue gas split in Backpass (%)				
Pri RH	43.95	43.95	45.20	43.64
Pri SH / Econ	56.05	56.05	54.80	56.36
Water/Steam Temperatures (°F)				
SH Out	999	999	1,005	1,005
RH Out	1,005	1,005	1,005	1,005
Percent Carbon in ash	0.446	0.992	0.445	0.992
ASME Heat Loss Efficiency (%)	88.98	88.90	88.95	88.73

* Conductance normalized with that at uprated nominal conditions (950 MW)

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Heat Duties (Additional Platen Surface Area)

	Uprated Nominal Baseline 950 MW	Uprated Nominal 10% OFA	Uprated Nominal Baseline 950 MW Additional Platen Area	Uprated Nominal 10% OFA Additional Platen Area
Flow Rates (1000 lb/hr)				
Main Steam	6,664	6,656	6,636	6,628
Reheat Steam	5,501	5,494	5,478	5,471
Attemperation flow (1000 lb/hr)				
Superheater	26	3	26	27
Reheater	0	0	0	0
Normalized waterwall conductance*	1.000	0.897	0.967	0.900
Water/Steam Temperatures (^{o}F)				
SH Out	999	999	1,005	1,005
RH Out	1,005	1,005	1,005	1,005
Heat Absorption (kW)				
Economizer	78,934	79,381	76,665	79,668
Waterwall	950,152	951,697	947,909	943,529
Primary SH	245,115	245,956	242,540	245,648
Platen SH	155,815	154,258	174,296	171,547
SH Int	242,479	237,965	234,501	232,710
SH Out	119,782	119,046	116,390	117,214
Pri RH	175,308	176,603	176,735	175,359
RH Out	166,082	164,608	163,794	161,979
Total Heat Absorption (kW)	2,133,667	2,129,514	2,132,830	2,127,654
ASME Heat Loss Efficiency (%)	88.98	88.90	88.95	88.73

* Conductance normalized with that at uprated nominal conditions (950 MW)

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Impact of Additional Platen Surface Area

- **Superheat attemperation recovers to the baseline value (~26 klb/hr)**
- **Very little change observed in the gas temperature distribution (similar results observed in CFD study)**
- **Additional platen heat absorption primarily effects heat absorption in upper furnace exchangers**
- **Additional platen superheater area with OFA modifications**
  - Helps maintain overall superheat absorption and attemperation buffer
  - Any minor reduction in reheater heat absorption can be controlled by adjusting the backpass mass split ratio

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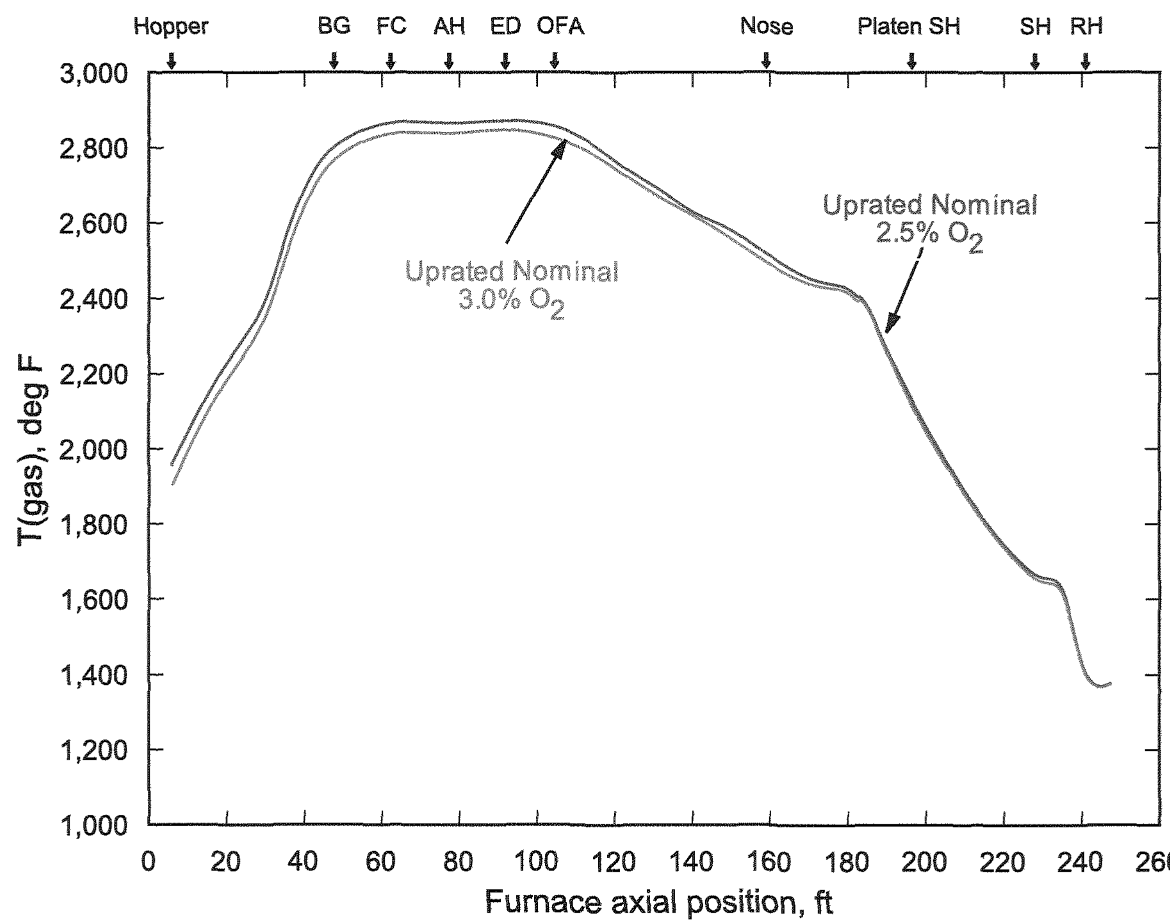
Boiler Performance with Increased Excess Air

- **Operation at 3 %$O_{2,wet}$**
  - Uprated nominal conditions
  - Additional platen surface area
  - No OFA
- **Slightly lower furnace gas temperatures**
  - More sensible gas heating



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Boiler Performance with Increased Excess Air

	Uprated Nominal Baseline, 2.5% O_2 950 MW Additional Platen SH area	Uprated Nominal Baseline, 3.0% O_2 950 MW Additional Platen SH area
Flue Gas O_2 (% wet)	2.50	3.00
Fuel Flow Rate (1000 lb/hr)	679	679
Flue gas Temperature (°F) Leaving		
FEGT	2,375	2,382
Economizer	728	738
Air Preheater Out	317	318
Flow Rates (1000 lb/hr)		
Main Steam	6,636	6,625
Reheat Steam	5,478	5,469
Attemperation flow (1000 lb/hr)		
Superheater	26	96
Reheater	0	0
Normalized Waterwall conductance*	0.967	1.000
Flue gas split in Backpass (%)		
Pri RH	45.20	42.57
Pri SH / Econ	54.80	57.43
Water/Steam Temperatures (°F)		
SHt Out	1,005	1,005
RH Out	1,005	1,005
Percent Carbon in ash	0.445	0.286
ASME Heat Loss Efficiency (%)	88.99	88.85

* Conductance normalized with that at uprated nominal conditions (950 MW)

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Impact of Excess Air on Thermal Performance

- **Waterwall fouling was reduced to recover waterwall heat absorption and maintain the primary steam rate**
- **Furnace gas temperatures are lower due to additional sensible heating in gas**
- **Carbon in ash is reduced because more oxygen is available in the lower furnace**
- **Higher gas mass flow increase convection heat transfer in the exchangers**
  - Compensates for slightly lower gas temperature driving force
  - Causes an increase in attemperation rate

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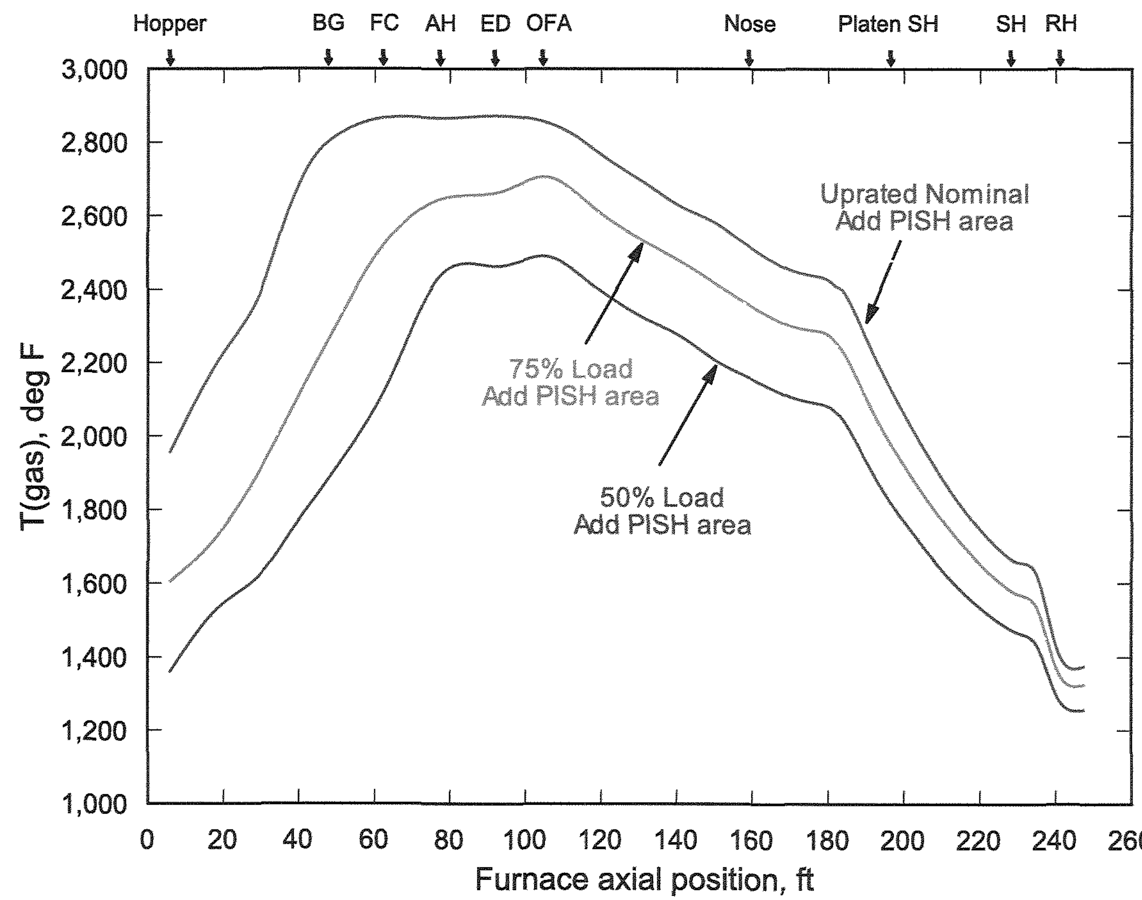
Boiler Performance with Load Changes

- **Low Load Conditions**
  - $\%O_{2,wet}$ taken from load curve
  - 75 percent uprated nominal load
    - 4.75 $\%O_{2,wet}$
    - Mills B, G, & F out of service
    - All burners in top rows
  - 50 percent uprated nominal load
    - 7.0 $\%O_{2,wet}$
    - Mills B, G, F, & C out of service
    - All burners in top rows
  - No OFA



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Boiler Performance with Load Changes

	Uprated Nominal Baseline 950 MW Additional Pl SH area	75% Nominal load Mills BGF OOS Additional Pl SH area	50% Nominal load Mills BGFC OOS Additional Pl SH area
Flue Gas O_2 (% wet)	2.50	4.75	7.00
Fuel Flow Rate (1000 lb/hr)	679	509	354
Flue gas Temperature (^oF) Leaving			
FEGT	2,375	2,221	2,045
Economizer	728	761	787
Air Preheater Out	317	304	291
Flow Rates (1000 lb/hr)			
Main Steam	6,636	4,970	3,482
Reheat Steam	5,478	4,103	2,874
Attemperation flow (1000 lb/hr)			
Superheater	26	55	9
Reheater	0	0	0
Normalized waterwall conductance*	0.967	0.967	0.885
Flue gas split in Backpass (%)			
Pri RH	45.20	39.40	33.90
Pri SH / Econ	54.80	60.60	66.10
Water/Steam Temperatures (^oF)			
SH Out	1,005	1,005	1,005
RH Out	1,005	1,005	976
Percent Carbon in ash	0.445	0.050	0.006
ASME Heat Loss Efficiency (%)	88.99	88.68	88.19

* Conductance normalized with that at uprated nominal conditions (950 MW)

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IGS Bituminous Fuel Characteristics

- **Fuel A is the baseline fuel**

	Fuel A	Fuel B	Fuel C	Fuel D	Fuel E
Proximate Analysis (mass % wet)					
Fixed Carbon	48.41	48.10	48.04	46.64	52.24
Volatiles	34.59	33.63	37.67	33.85	34.53
Moisture	6.32	6.06	6.98	8.71	5.46
Ash	10.68	12.21	7.31	10.80	7.77
Total	100.00	100.00	100.00	100.00	100.00
Ultimate Analysis (mass % dry)					
C	71.10	70.00	74.54	70.66	74.80
H	5.01	5.57	5.72	5.73	5.55
N	1.48	1.81	1.77	1.85	1.79
O	10.33	8.92	9.50	9.39	8.45
S	0.68	0.70	0.61	0.54	1.20
Ash	11.40	13.00	7.86	11.83	8.21
Total	100.00	100.00	100.00	100.00	100.00
Higher Heating Value (Btu/lb, wet)	11,927	11,751	12,597	11,321	12,883

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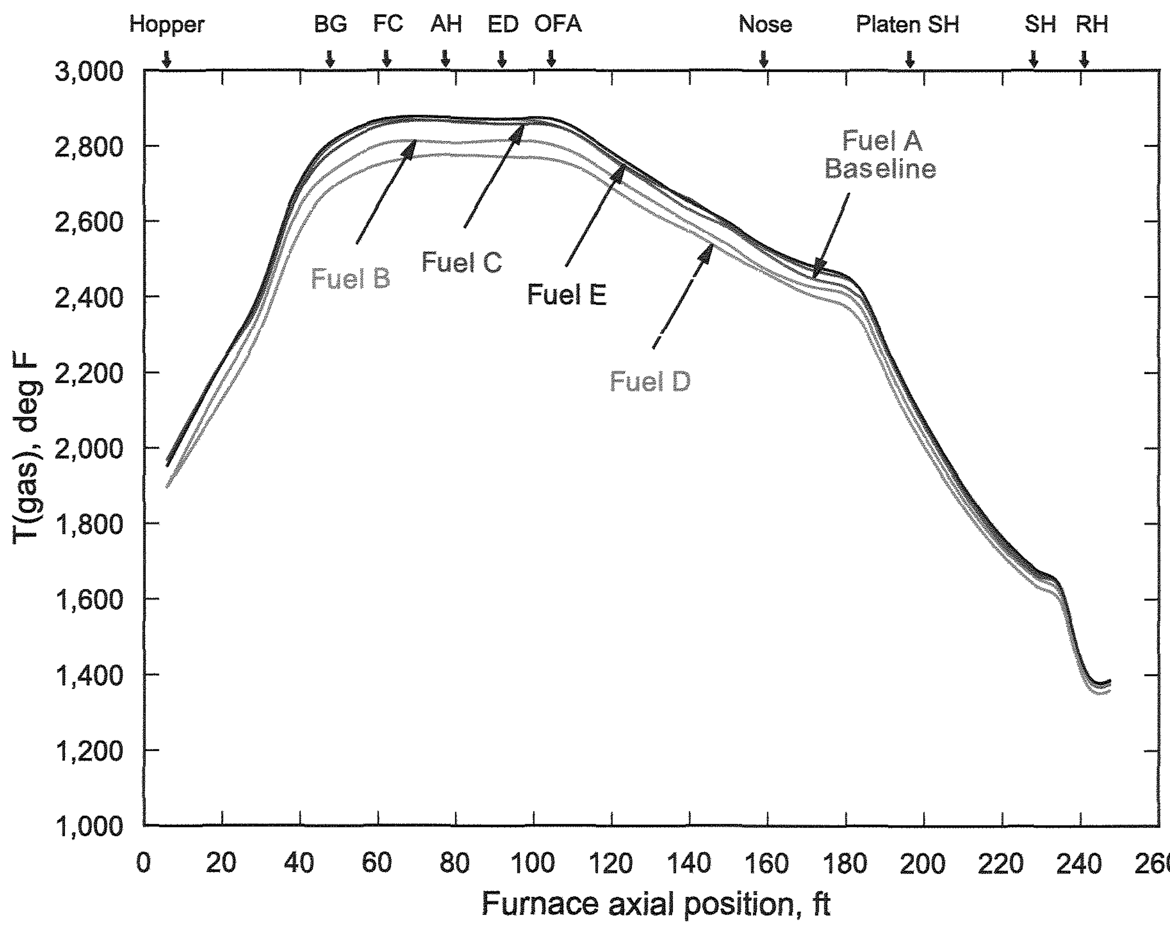
Boiler Performance with Different Fuels

- **Operation with different fuel types**
  - Fuels analyses from IPSC
  - Uprated nominal load conditions
  - No OFA
  - Additional platen surface area
  - Fuel rate scaled based on required heat input and HHV



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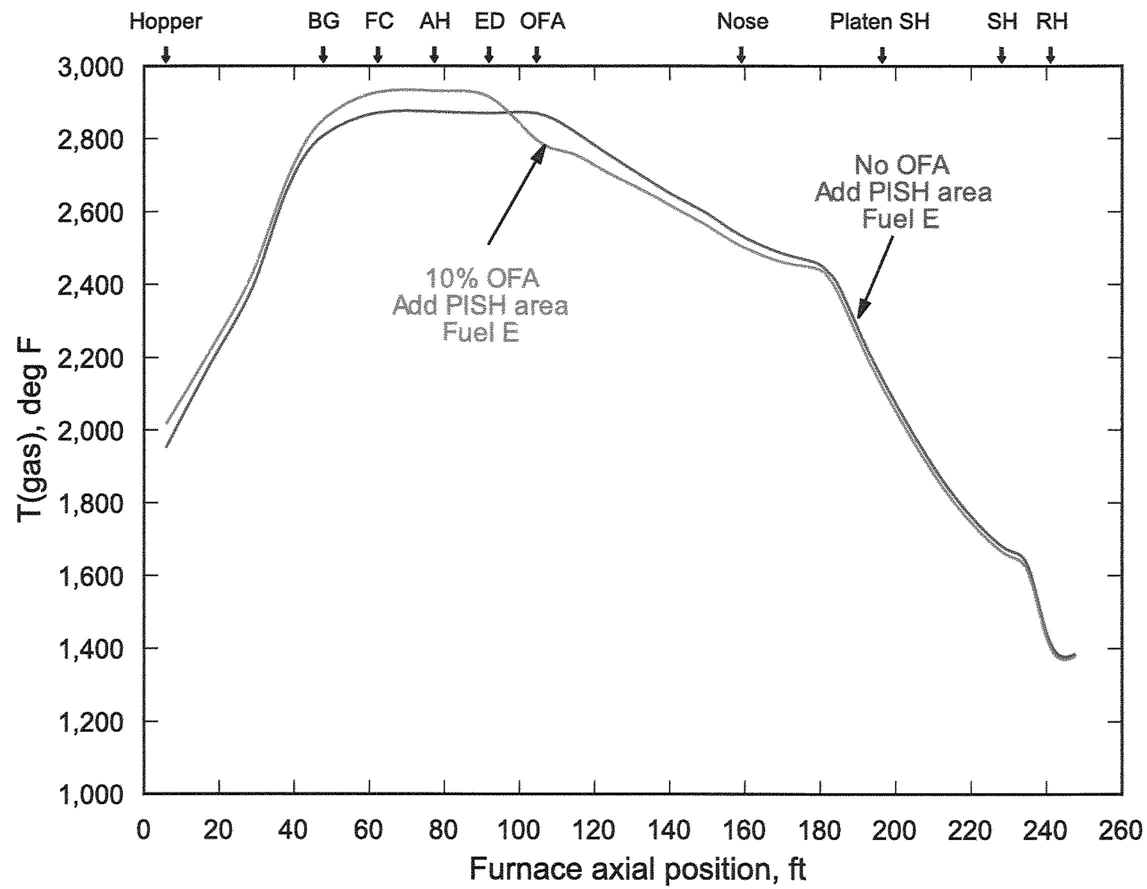
Boiler Performance with Different Fuels

	Uprated Nominal Baseline 950 MW Fuel A	Uprated Nominal Baseline 950 MW Fuel B	Uprated Nominal Baseline 950 MW Fuel C	Uprated Nominal Baseline 950 MW Fuel D	Uprated Nominal Baseline 950 MW Fuel E
Flue Gas O_2 (% wet)	2.50	2.50	2.50	2.50	2.50
Fuel Flow Rate (1000 lb/hr)	679	692	644	720	629
Flue gas Temperature (°F) Leaving					
FEGT	2,375	2,345	2,397	2,345	2,389
Economizer	728	754	743	735	740
Air Preheater Out	317	320	313	319	312
Flow Rates (1000 lb/hr)					
Main Steam	6,636	6,609	6,635	6,589	6,655
Reheat Steam	5,478	5,456	5,477	5,439	5,493
Attemperation flow (1000 lb/hr)					
Superheater	26	84	103	85	99
Reheater	0	0	0	0	0
Normalized waterwall conductance*	0.967	1.025	0.967	1.072	0.967
Flue gas split in Backpass (%)					
Pri RH	45.20	39.47	40.12	39.91	40.61
Pri SH / Econ	54.80	60.53	59.88	60.09	59.39
Water/Steam Temperatures (°F)					
SH Out	1,005	1,005	1,005	1,005	1,005
RH Out	1,005	1,005	1,005	1,005	1,005
Percent Carbon in ash	0.445	0.488	0.643	0.579	0.826
ASME Heat Loss Efficiency (%)	88.99	88.27	88.75	87.69	89.07

* Conductance normalized with that at uprated nominal conditions (950 MW)

OFA Gas Temperatures with Fuel E

- **10% OFA Operation with Fuel E**
  - Examine OFA impact on carbon-in- ash
  - Uprated nominal load conditions
  - Fuel rate scaled based on required heat input and HHV



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OFA Thermal Performance with Fuel E

	Uprated Nominal Baseline 950 MW Fuel E Additional Platen SH area	Uprated Nominal 10% OFA Fuel E Additional Platen SH area
Flue Gas O_2 (% wet)	2.50	2.50
Fuel Flow Rate (1000 lb/hr)	629	629
Flue gas Temperature (^oF) Leaving		
FEGT	2,389	2,342
Economizer	740	725
Air Preheater Out	312	311
Flow Rates (1000 lb/hr)		
Main Steam	6,655	6,659
Reheat Steam	5,493	5,497
Attemperation flow (1000 lb/hr)		
Superheater	99	52
Reheater	0	0
Normalized waterwall conductance*	0.967	0.967
Flue gas split in Backpass (%)		
Pri RH	40.61	43.59
Pri SH / Econ	59.39	56.41
Water/Steam Temperatures (^oF)		
SH Out	1,005	1,005
RH Out	1,005	1,005
Percent Carbon in ash	0.826	1.806
ASME Heat Loss Efficiency (%)	89.07	89.00

* Conductance normalized with that at uprated nominal conditions (950 MW)

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Fuels Impact on Boiler Thermal Performance

- **Lower HHV fuels produced lower furnace gas temperatures**
  - More fuel/air increases gas sensible heating
- **Compared with Fuel A, higher/lower HHV fuels required more/less waterwall fouling**
- **Fuel E produces the greatest amount of carbon in ash**
  - With no OFA, carbon in ash is 0.83%
  - With 10% OFA, carbon in ash is 1.81%

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Estimated Tube Metal Temps. (Max.)

- **Platen Exchanger (shown in table) – 852 - 861 °F**

	Uprated Nominal (950 MW)	Uprated Nominal 5% OFA	Uprated Nominal 10% OFA	Uprated Nominal 15% OFA	Uprated Nominal Add Pl SH Area	Uprated Nominal Add Pl SH Area 10% OFA
Heat Duty (kW)	155,815	153,132	154,258	148,681	174,296	171,547
Exchanger Surface Area (m^2)	2044.91	2044.91	2044.91	2044.91	2365.69	2365.69
Heat Flux (kW/m^2)	76.20	74.88	75.43	72.71	73.68	72.51
Heat Flux ($kBtu/hr\text{-}ft^2$)	24.16	23.75	23.92	23.06	23.36	22.99
Tube Outer Diameter (m)	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508
Tube Thickness (m)	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093
Tube Wall Thermal Conductivity (kW/m-K)	0.0216	0.0216	0.0216	0.0216	0.0217	0.0217
Tube Wall Thermal Conductance ($kW/m^2\text{-}K$)	1.87	1.87	1.87	1.87	1.88	1.88
Temperatures (°F)						
Pri SH Out	721	722	721	724	721	722
Platen SH Out	781	781	781	782	790	791
Steam Average	751	752	751	753	756	757
Estimated Ave. Tube Wall	824	823	824	823	826	826
Estimated Max. Tube Wall	854	853	853	852	861	861

- **SH Int. – 966 - 962 °F**
- **SH Out – 1018 - 1020 °F**
- **RH – 1022 - 1023 °F**
- **Waterwall (second burner row) – 943 - 963 °F**

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Conclusions

- **Overfire Air Operation**
  - Use of OFA expected to increase carbon-in-ash and reduce main steam attemperation.
  - Increased furnace fouling necessary to maintain steam temperatures and/or attemperation rates.
  - Overall impacts of OFA operation on boiler performance are minimal.
- **Platen Modification**
  - Platen modification increases main steam attemperation rates, even with OFA operation.
  - Overall boiler performance maintained with upgrade.
  - Boiler performance can be maintained for range of fuels burned, provided that furnace heat absorption can be controlled to accommodate fuel characteristics.
  - Boiler performance can be maintained with increased excess air, but attemperation rates projected to increase.

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GE Power Systems

CFD Furnace Modeling of the Upgraded IGS Unit 1&2 Steam Generators

4 February 2003

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Irvine, CA 92618
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Presentation Outline

- Introduction
- Model Geometry
- Case Studies
- Conclusions

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Introduction

- **Objectives of Furnace CFD Study**
  - Predict local gas temperatures and compositions
  - Evaluate OFA-flue gas mixing effectiveness
  - Project the impacts of OFA on CO production and distribution relative to baseline conditions
  - Examine conditions with and without additional platen exchanger area

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Introduction

- **Furnace CFD Modeling Approach**
  - Fluent 6.0 CFD software used
  - Mesh size – 347,435 cells
  - Submodels
    - k-ε turbulence mixing model
    - Eddy-dissipation combustion model (gas phase)
    - Discrete-ordinates radiation model
    - Discrete-phase combustion model (char burnout)
  - Exchanger modeling
    - Porous media simulating pressure drop
    - Volumetric heat sinks

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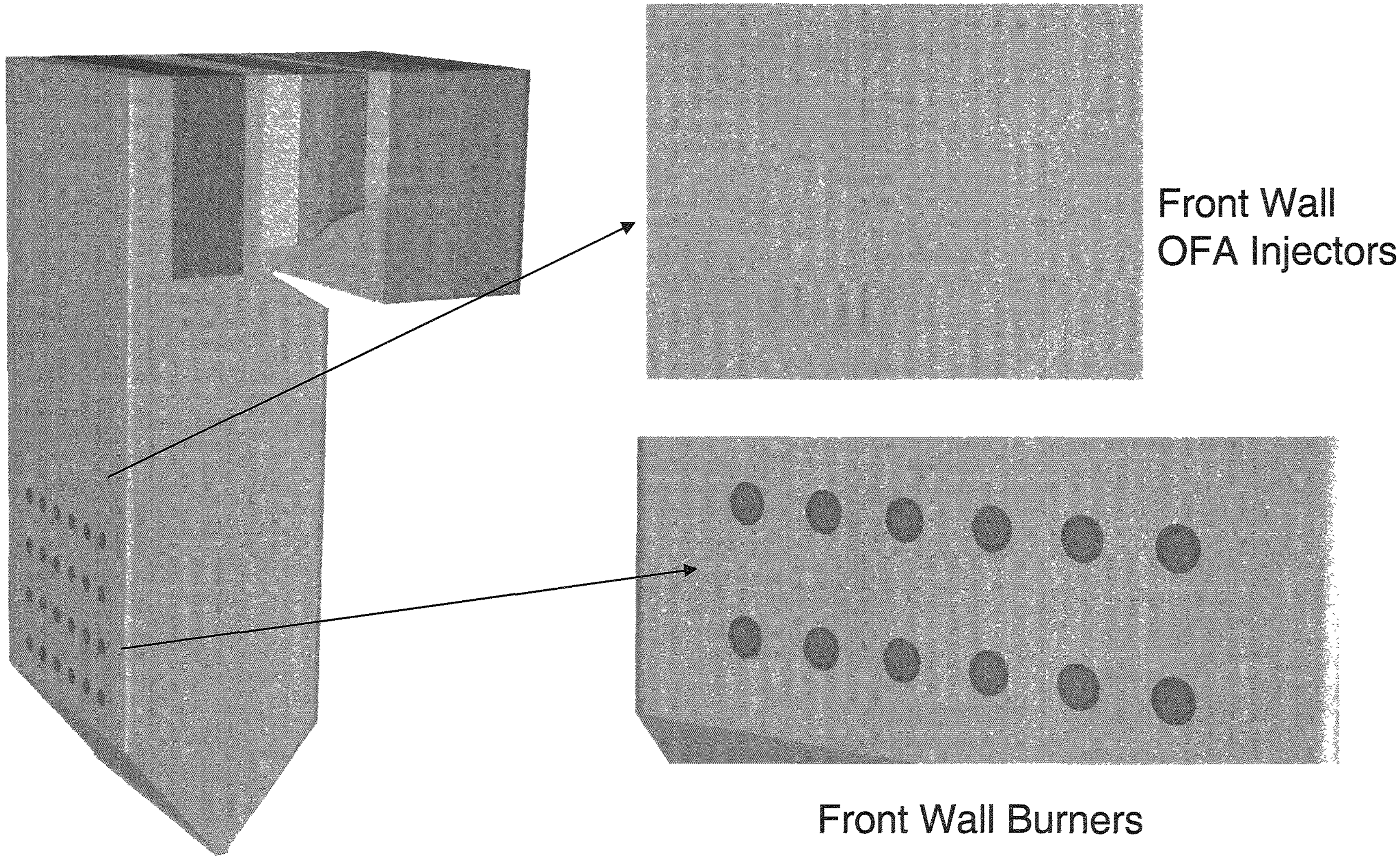
IGS Boiler Geometry



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Introduction

Model Calibration and Cases

- **Match results from thermal code**
  - Wall temperatures
  - Exchanger heat duties
  - Parameter settings (e.g. OFA flow rate, $\%O_2$, etc.)
- **Adjust turbulent mixing parameters to generate ~100 ppm CO for baseline conditions (specified by IPSC)**

Case Type	Load	OFA Injector Characteristics	Fuel Type	OFA % Total Air	$\% O_{2,wet}$
OFA without Platen SH Upgrade	Uprated Nominal (950 MW)	Fully Open, 2/3 open	Fuel A	0, 10	2.5
OFA with Platen SH Upgrade	Uprated Nominal	Fully Open	Fuel A	0, 10	2.5

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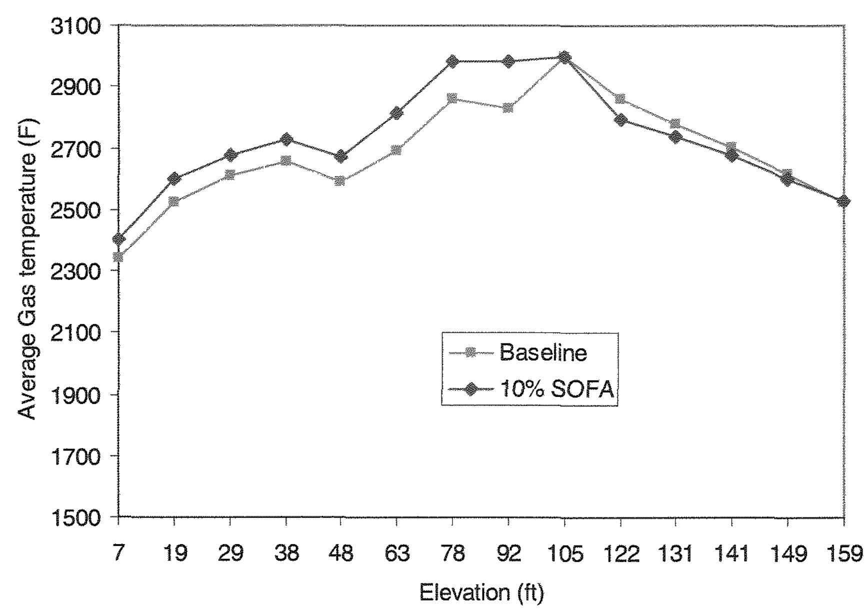
Average Model Results

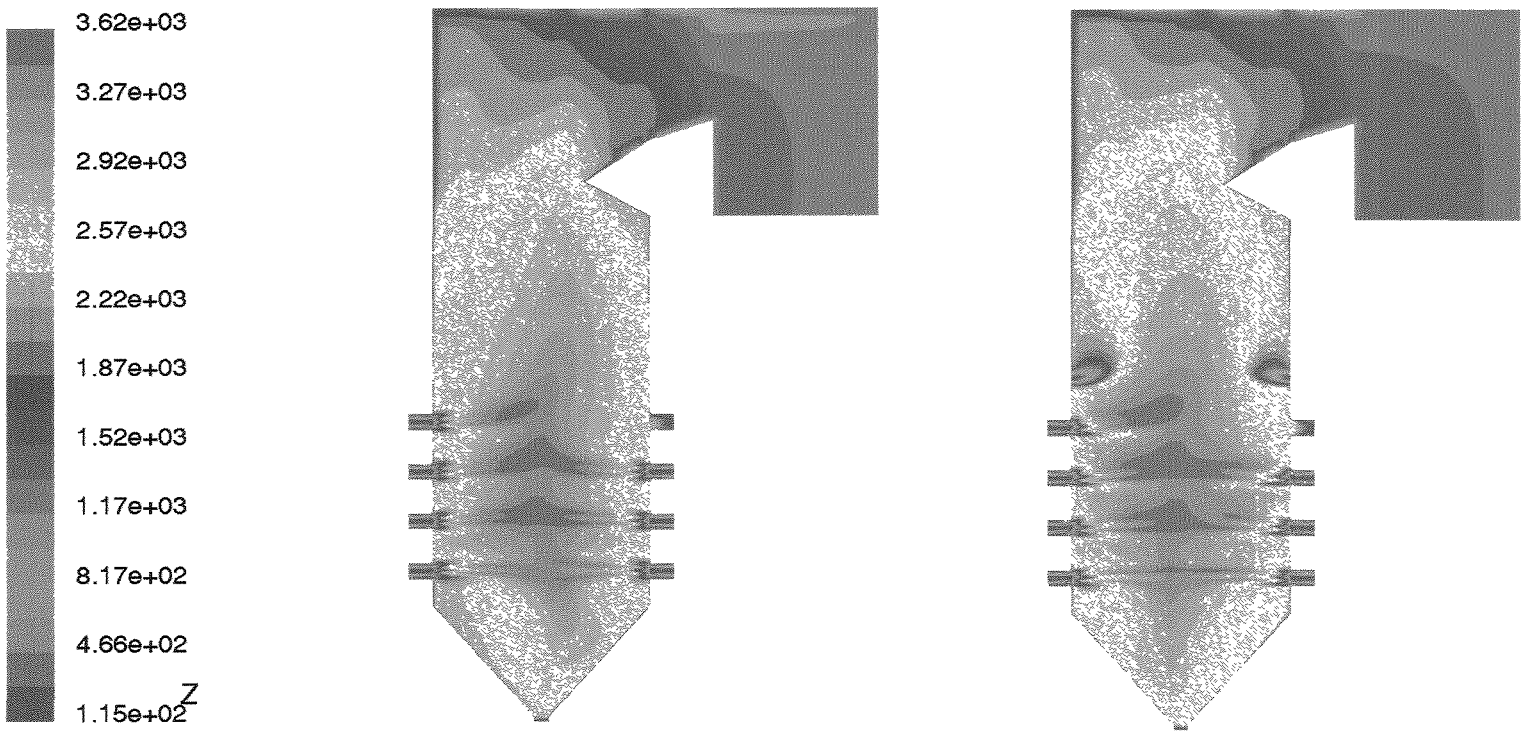
- **10% OFA compared with baseline conditions**
- **CO concentration at backpass exit doubles with 10% OFA**
- **Average Gas Temperatures**
  - Comparison is up to nose plane
  - Gas temperature profiles similar to those generated by thermal model with OFA
    - Higher gas temperatures in burner region
    - Lower gas temperatures above OFA injectors
    - Temperature recovers above nose

Input		Baseline	10% SOFA
Primary Air	lb/hr	1,249,539	1,249,539
Secondary Air	lb/hr	5,692,320	4,998,120
SOFA	lb/hr	0	694,200
Coal Flow	lb/hr	679,000	679,000
Output			
Exit O2 (wet)	%	2.56	2.57
Exit CO (wet)	ppm	102	199



Side View of Temperature Contour

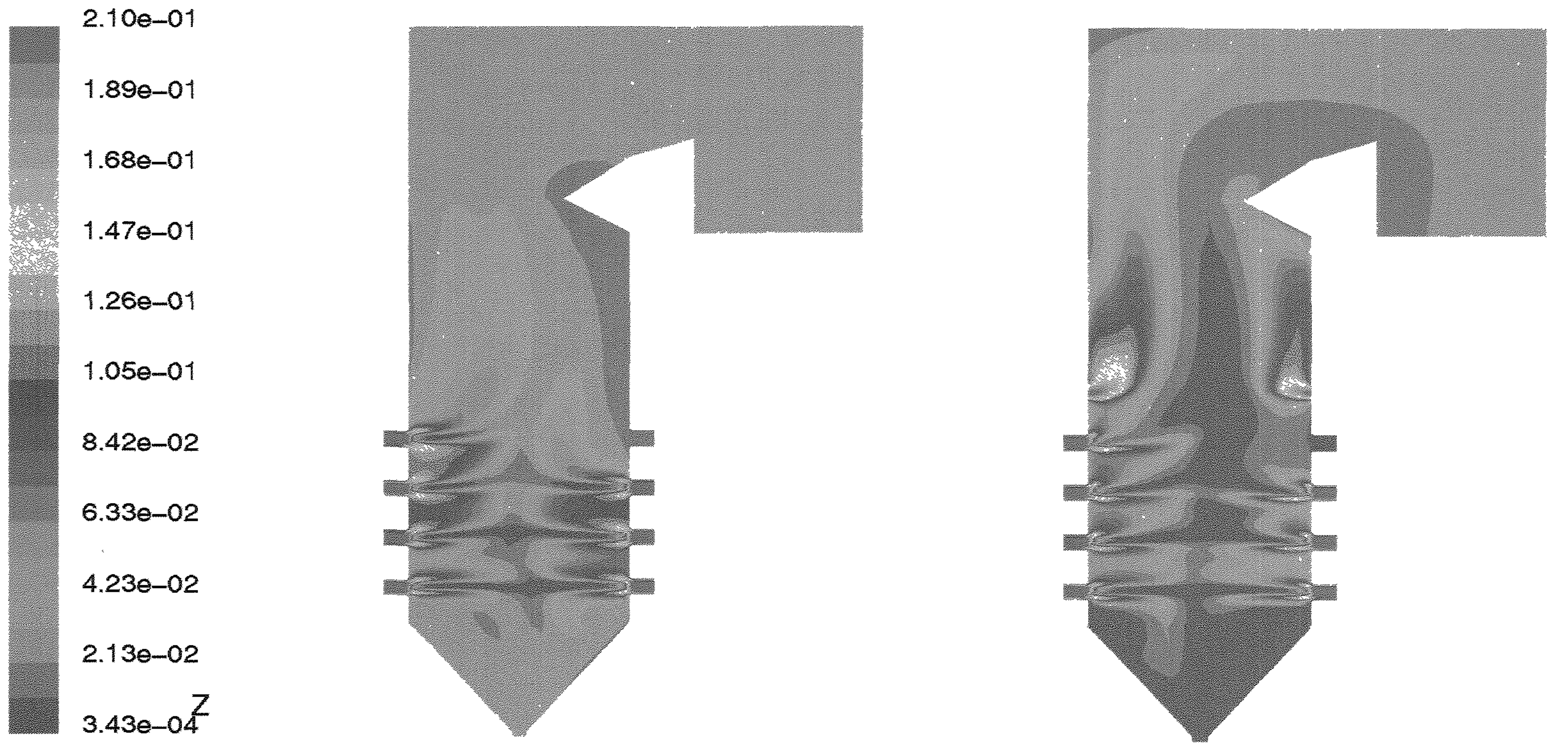
- **Comparison of 10% and baseline conditions**
  - Higher temperatures in the burner region with OFA
  - Slightly lower temperatures near OFA injectors
  - Temperature contours are similar in the upper furnace



T (deg. F) | Baseline | 10% OFA

Side View of O_2 Mole Fraction Contour

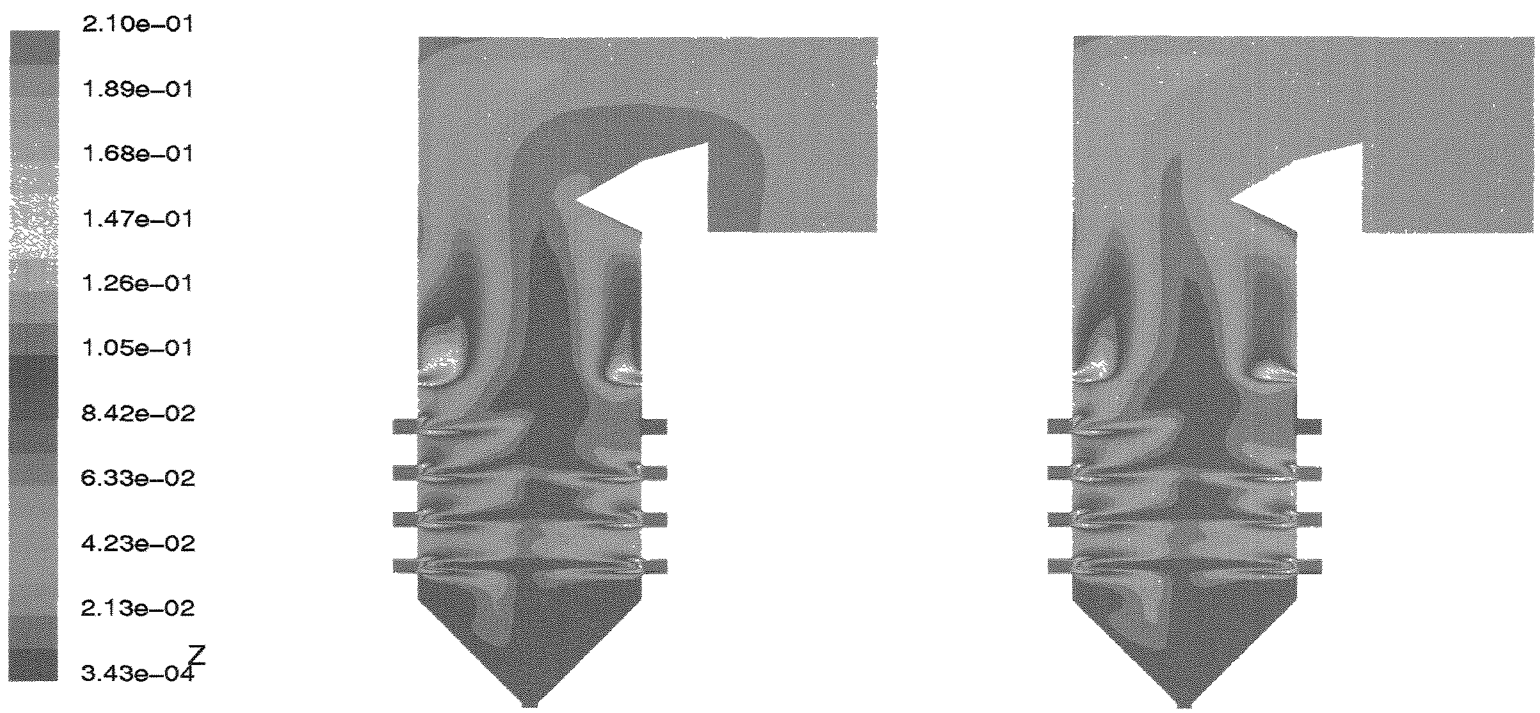
- **Comparison of 10% OFA to Baseline Conditions**
  - Oxygen depleted in the center of furnace just above the OFA injectors
  - OFA jets do not penetrate deeply into furnace
  - Oxygen distribution relatively uniform in upper furnace



Mole Fraction Baseline 10% OFA

Side View of O_2 Mole Fraction Contour

- **Comparison of OFA port full open to 2/3 open**
  - OFA injector area reduced to increase velocity
  - Small improvement in jet penetration
  - Small improvement in upper furnace mixing
  - CO reduced from 199 to 191 ppm



Mole Fraction

OFA Ports Fully Open

OFA Ports 2/3 Open

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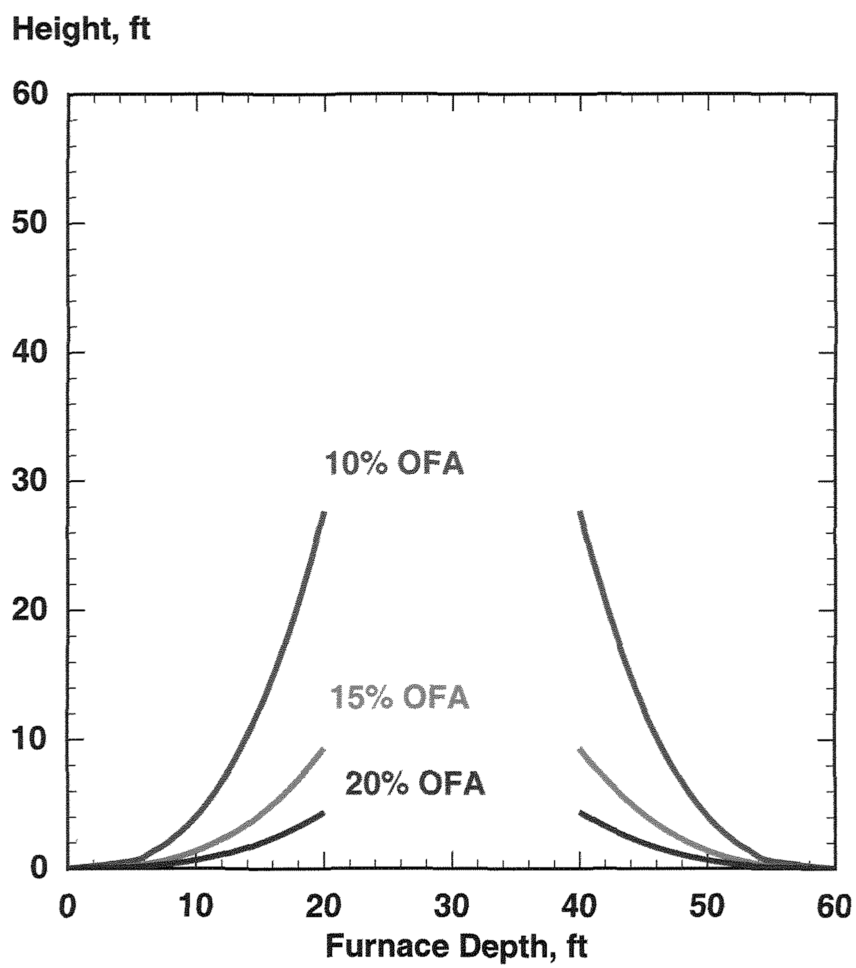
Jet-In-Crossflow Analysis

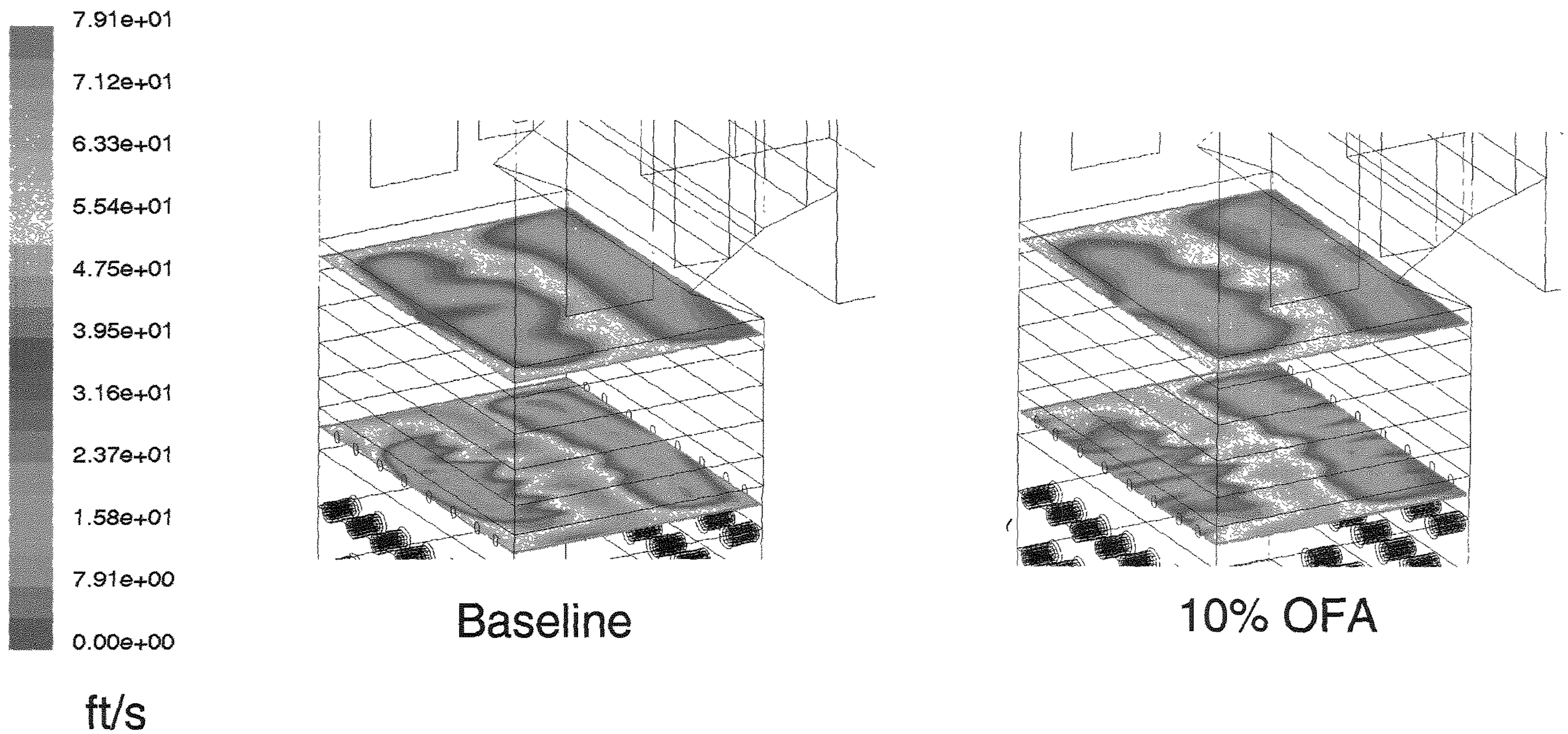


- **Predicted centerline trajectory for overfire air jet in a uniform stream.**
- **Increasing overfire air flow rate (jet mass flow and velocity) improves jet penetration and mixing rate.**

IP7_037181

Velocity Magnitude

- **Comparison of 10% OFA with baseline conditions**
  - Flue gas from burners is centered in furnace resulting in high velocities
  - Higher velocities also occur on the side wall and on the front wall near the sidewalls.
  - Non-uniform velocity profile impacts OFA jet penetration.



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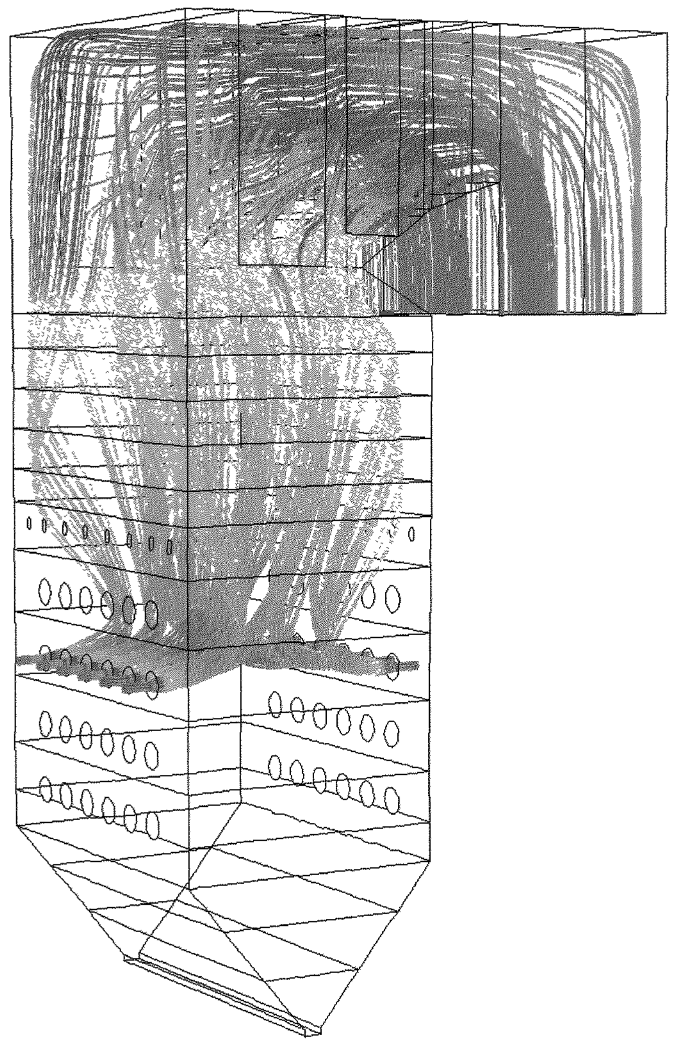
Burner Path Lines (Baseline Conditions)



- **Burner path lines at baseline conditions**
  - Lines colored by temperature
  - Path lines track a lump of fluid through its flow path
  - Flow concentrates at the furnace center in burner region
  - Flow expands outward above burner region

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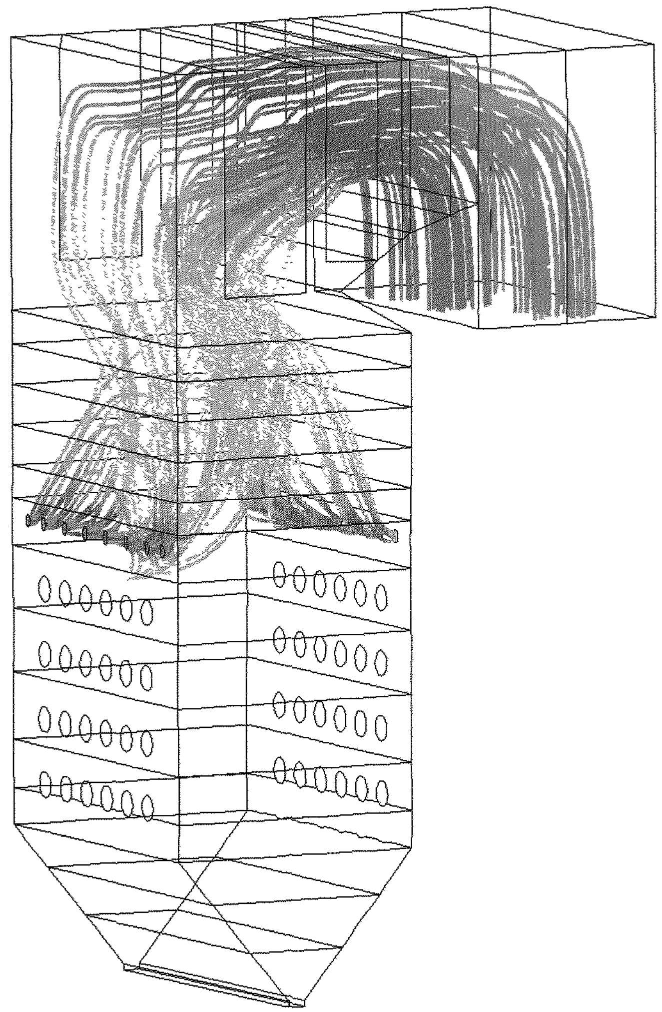
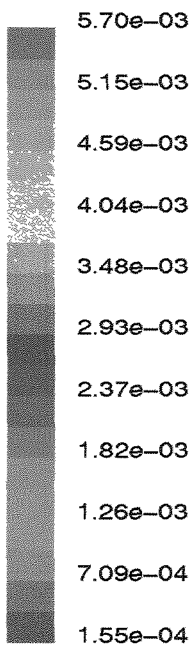
OFA Path Lines



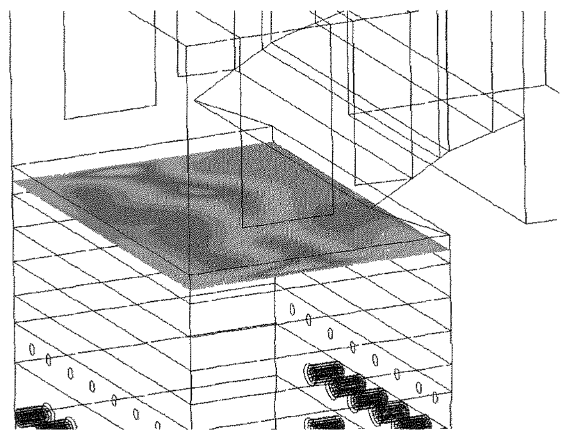
- **Path lines at 10% OFA**
  - Equal mass flow in all OFA injectors
  - OFA entrained downward by upper front-wall burner row
  - Less OFA entrainment on rear-wall injectors row (likely due to upper burner row being out of service)

CO Mole Fraction Contour

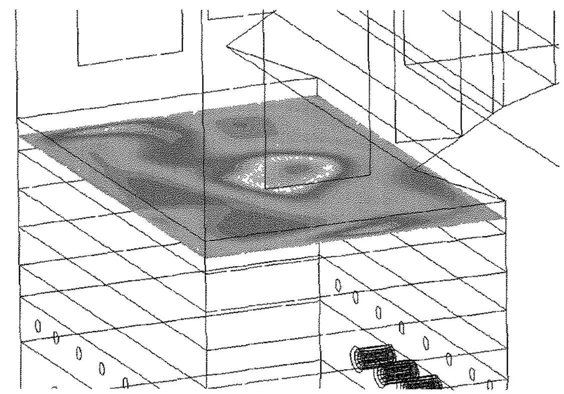
- **Comparison of 10% OFA with baseline conditions**
  - Contour plane positioned just below the nose
  - CO is concentrated across center of boiler
  - Operation with OFA increases CO concentration in center region, with bias towards rear wall



Mole Fraction



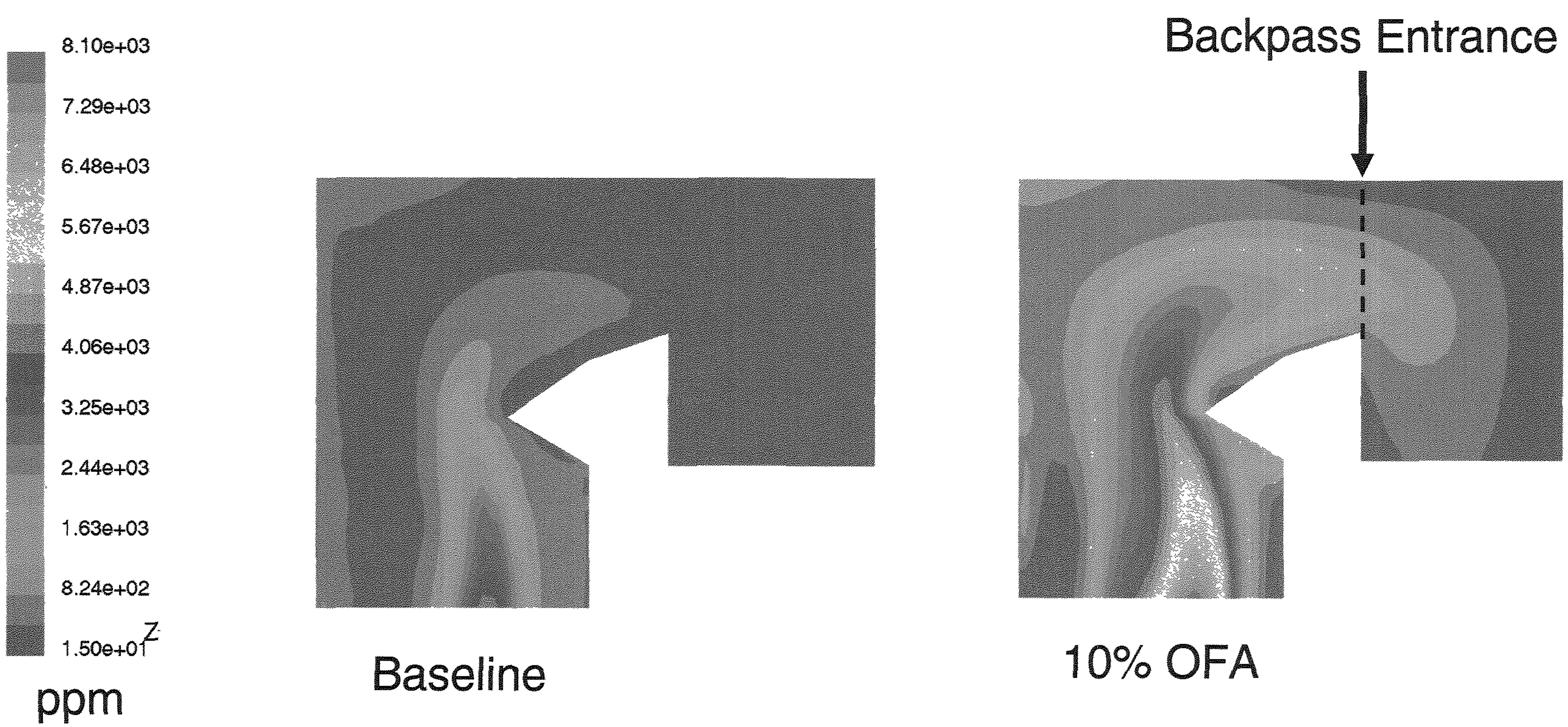
Baseline



10% OFA

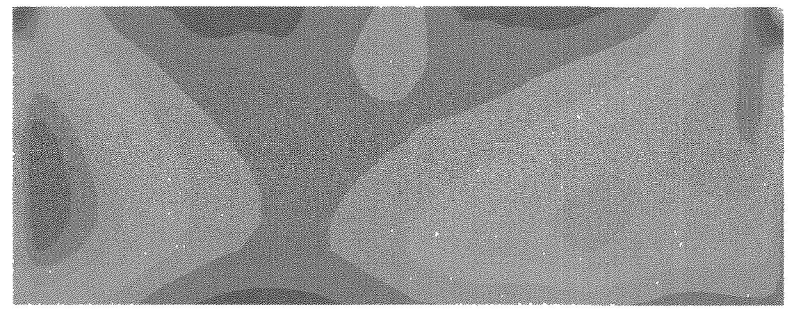
CO Concentration (ppm) Above OFA Elevation

- **Comparison of 10% OFA with baseline conditions**
  - Contour plane positioned on burner column
  - CO oxidation continues as flue gas enters upper furnace
  - Elevated CO levels are in center of furnace entering backpass

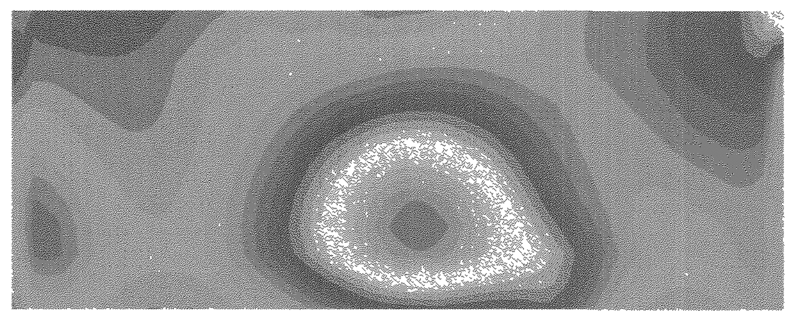


CO Concentration (ppm) at Backpass Entrance

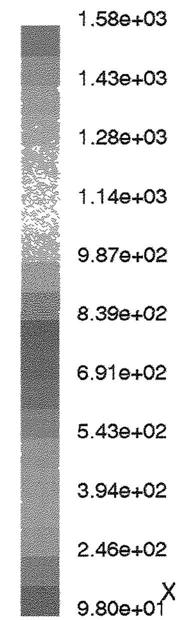
- **Vertical planar cut at the backpass entrance**
- **Comparison between 10% OFA and baseline conditions**
  - CO concentrated in lower central portion of plane with 10% OFA
  - Oxidation continues into the backpass superheater and reheater (~1600 ^{o}F)



Baseline



10% OFA



ppm

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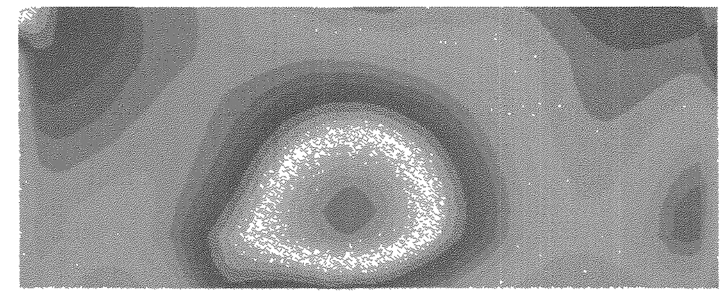
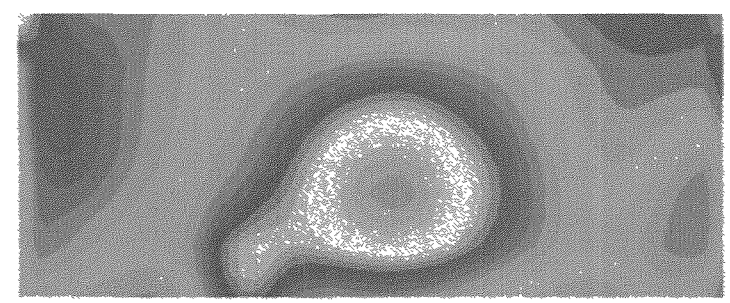
CO Concentration (ppm) at Backpass Entrance

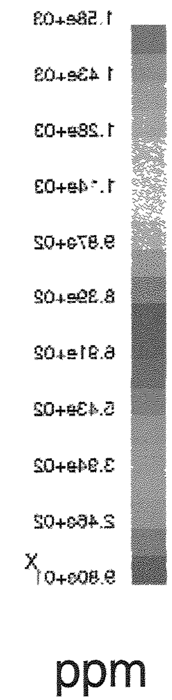
- **Vertical planar cut at the backpass entrance**
- **Comparison of different OFA injection velocities**
  - 10% OFA conditions
  - Injector mass flow rate constant
  - Injector cross-section reduced to increase injection velocity
  - CO concentration reduced slightly at higher injection velocity



OFA Ports Fully Open



OFA Ports 2/3 Open



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Comparison with Added Platen Surface Area

- **The CFD model predicts that addition of platen surface area will not cause significant changes in CO levels or gas temperatures**
- **Temperature impacts agree with boiler thermal model**

Input		Baseline	10% SOFA	Baseline w/Platen Mods	10% SOFA w/ Platen Mods
Primary Air	lb/hr	1,249,539	1,249,539	1,249,539	1,249,539
Secondary Air	lb/hr	5,692,320	4,998,120	5,692,320	4,998,120
SOFA	lb/hr	0	694,200	0	694,200
Coal Flow	lb/hr	679,000	679,000	679,000	679,001
Output					
Exit O2 (wet)	%	2.56	2.57	2.56	2.57
Exit CO (wet)	ppm	102	199	102	194

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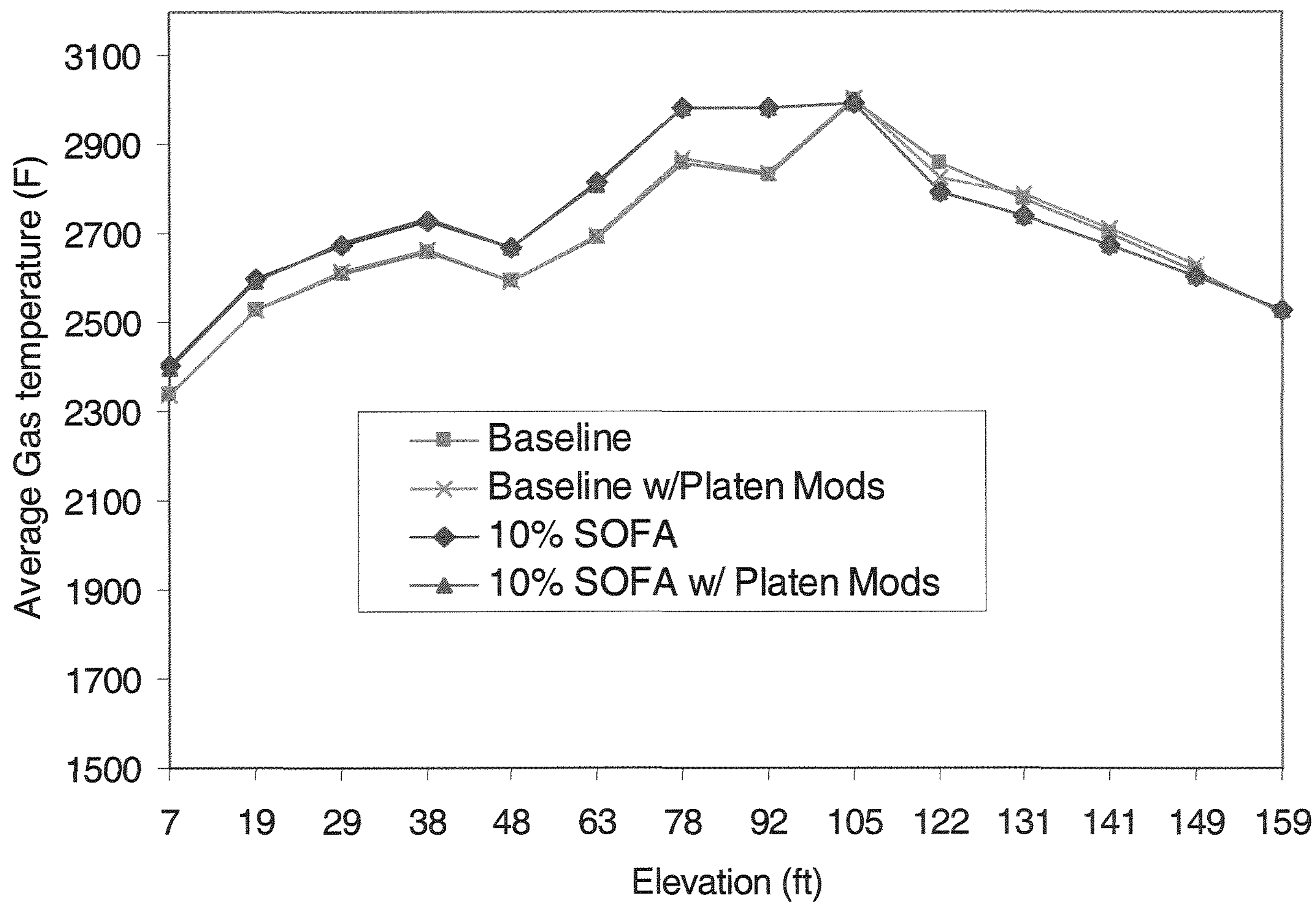
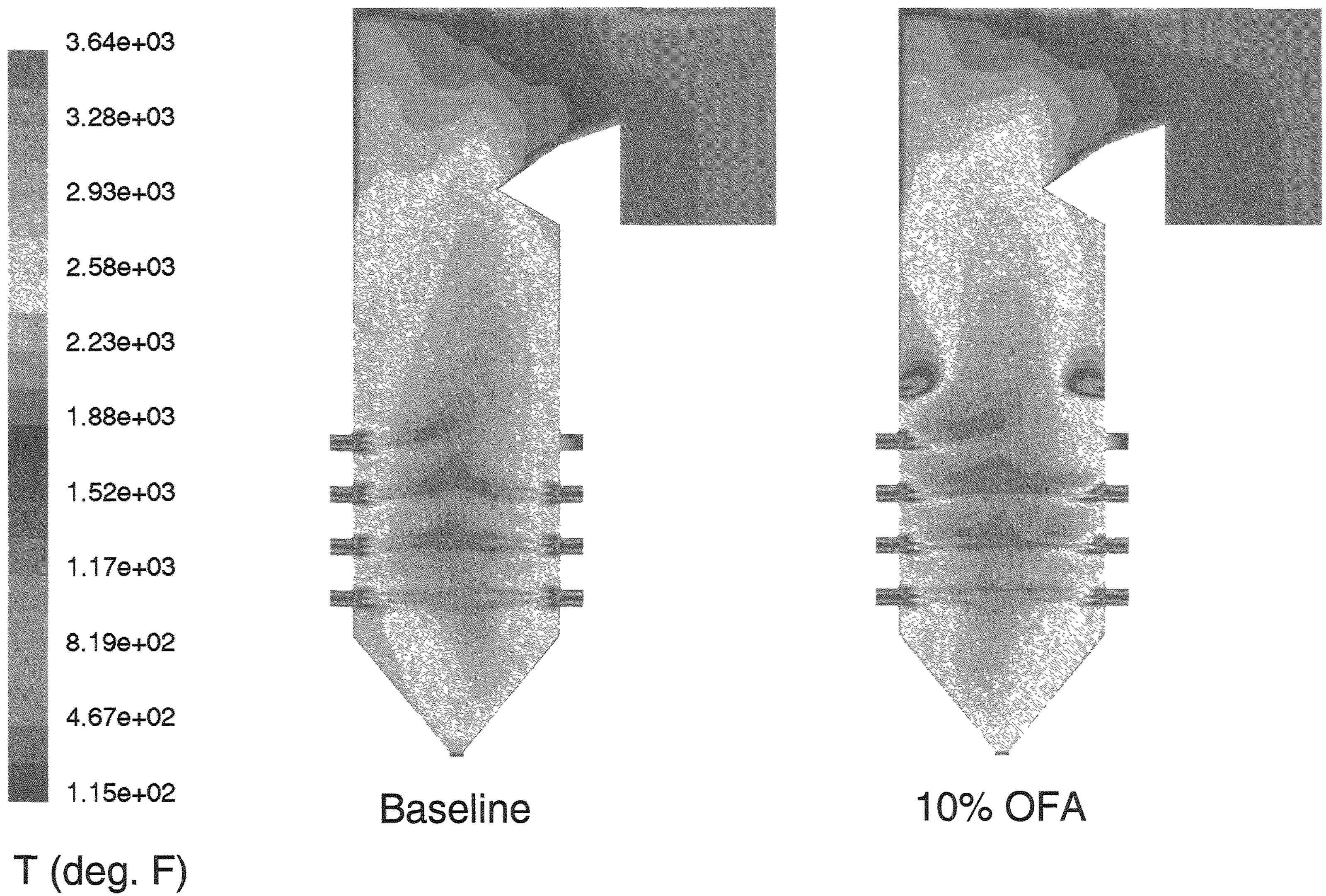
Average Gas Temperature



Comparison is up to the nose elevation.

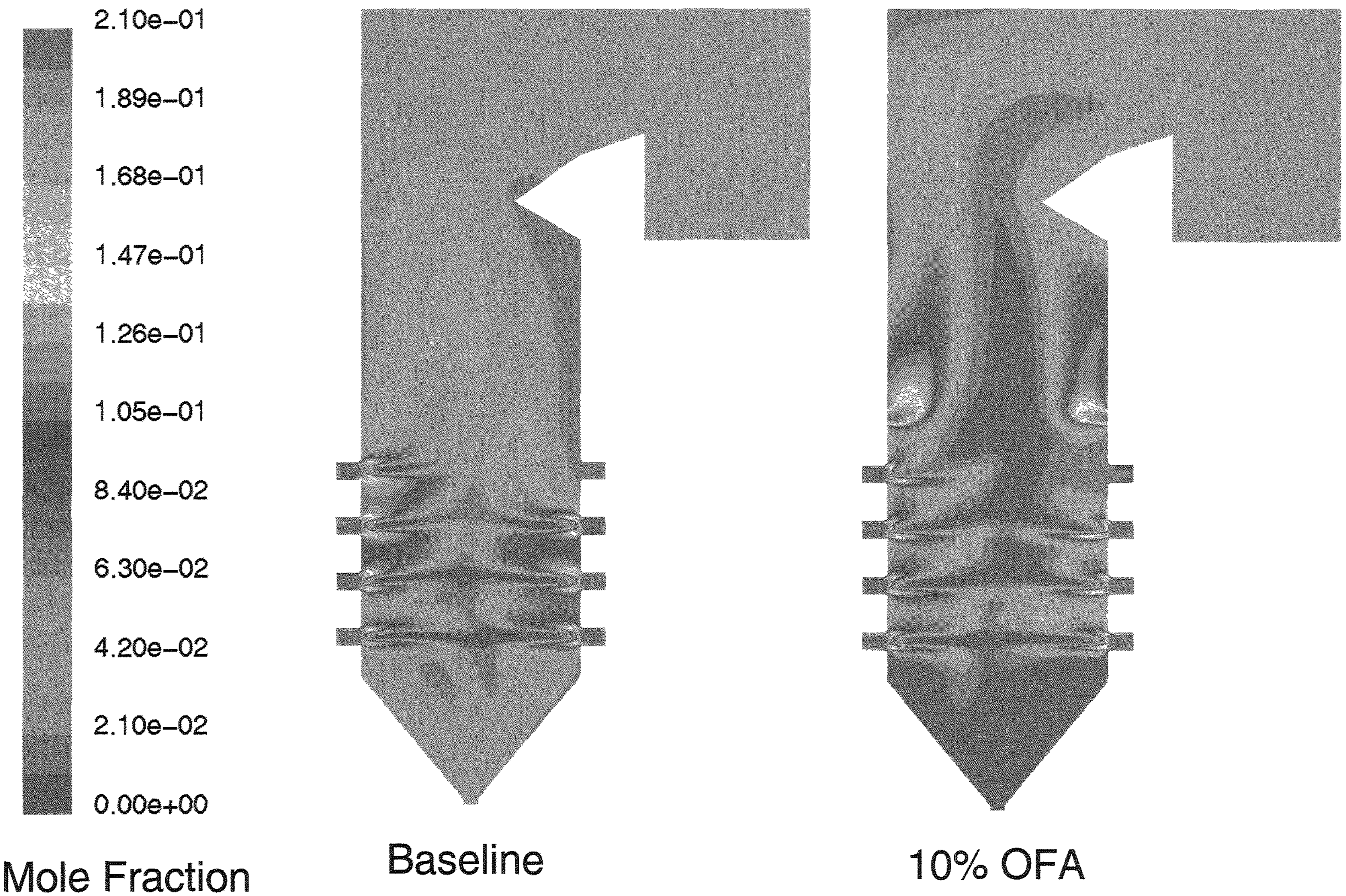
Side View of Temperature Contour

Additional Platen Surface Area



Side View of O_2 Mole Fraction Contour

Additional Platen Surface Area



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Conclusions

- CFD applied to predict furnace flow patterns, temperatures, flue gas compositions for baseline operation and for operation with OFA and the platen exchange upgrade
- Upgrading the platen exchange surface area expected to have a minor impact on the furnace parameters evaluated
- The furnace flow field is non-uniform, but typical of opposed wall fired boilers
- At 10% OFA, the OFA jets do not achieve deep penetration across the furnace cross section, operation with the 1/3 damper closed results in a small increase in penetration
- OFA mixing and CO oxidation continues as the flue gas enters the backpass, however, CO emissions are projected to increase with 10% OFA.

GE Power Systems

Computer Modeling of the Upgraded IGS Unit 1&2 Steam Generators

4 February 2003

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Presentation Outline

- Objective
- Approach
- Summary
- Conclusions

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Objective

- **Apply engineering analysis tools to evaluate the impacts of boiler modifications (platen superheater upgrade and overfire air) on:**
  - Boiler performance (generation, steam temperatures, efficiency)
  - Tube metal and burner temperatures
  - Carbon-in-ash
  - NO_X emissions
  - CO emissions
- **Evaluate mixing effectiveness of proposed overfire air injector design**

Approach

Boiler Performance →	**Furnace/Boiler Model** (Steam generation, steam/flue gas temperatures, carbon loss, boiler efficiency, metal temperatures)
OFA Mixing Performance	
→	**Furnace CFD Model** (Detailed furnace profiles, CO emissions)
CO Emissions	
Burner Metal Temperature →	**Burner CFD Model** (Metal temperatures)
NOx Emissions →	**Process Model** (NOx emissions projections with OFA)

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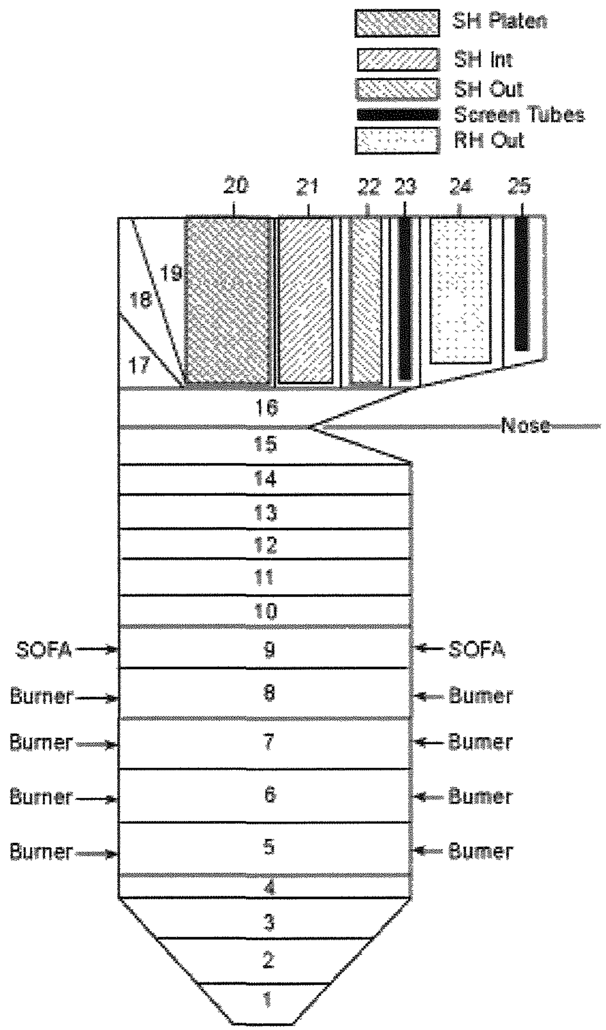
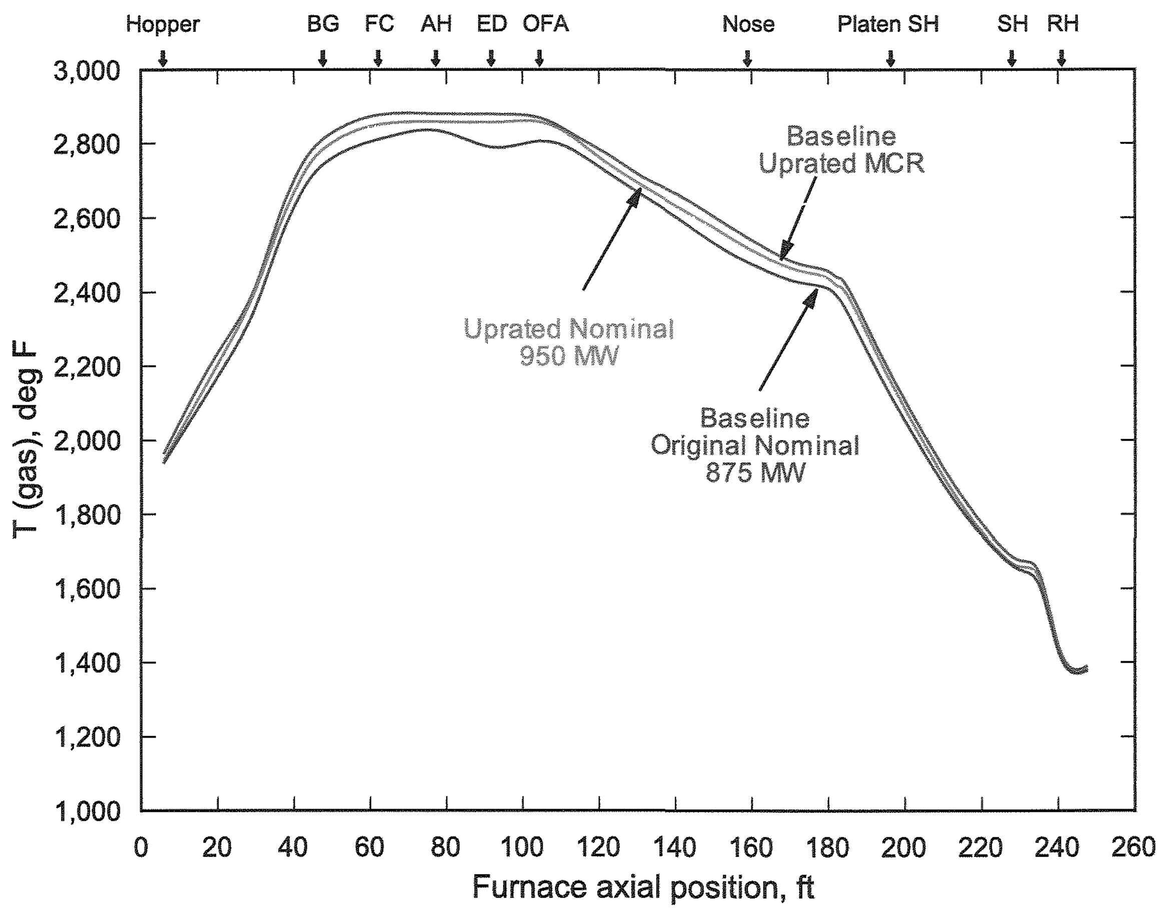
Boiler Performance Analysis



a) Furnace division into layers

Model Geometry and Mean Furnace Gas Temperature Profile



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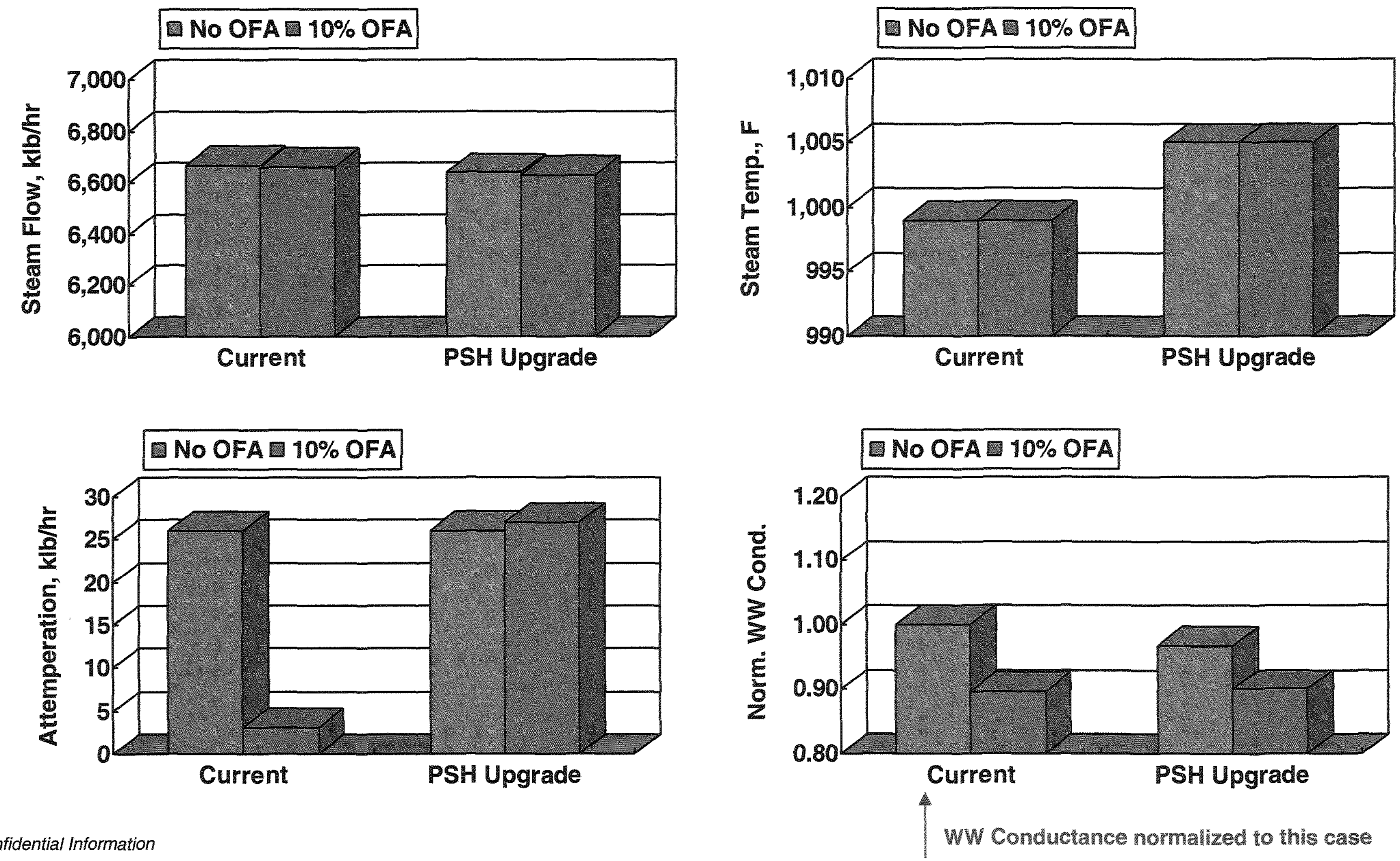
Boiler Performance Analysis

Uprated Nominal Load (950 MW)

Comparison of impacts of OFA and PSH upgrade



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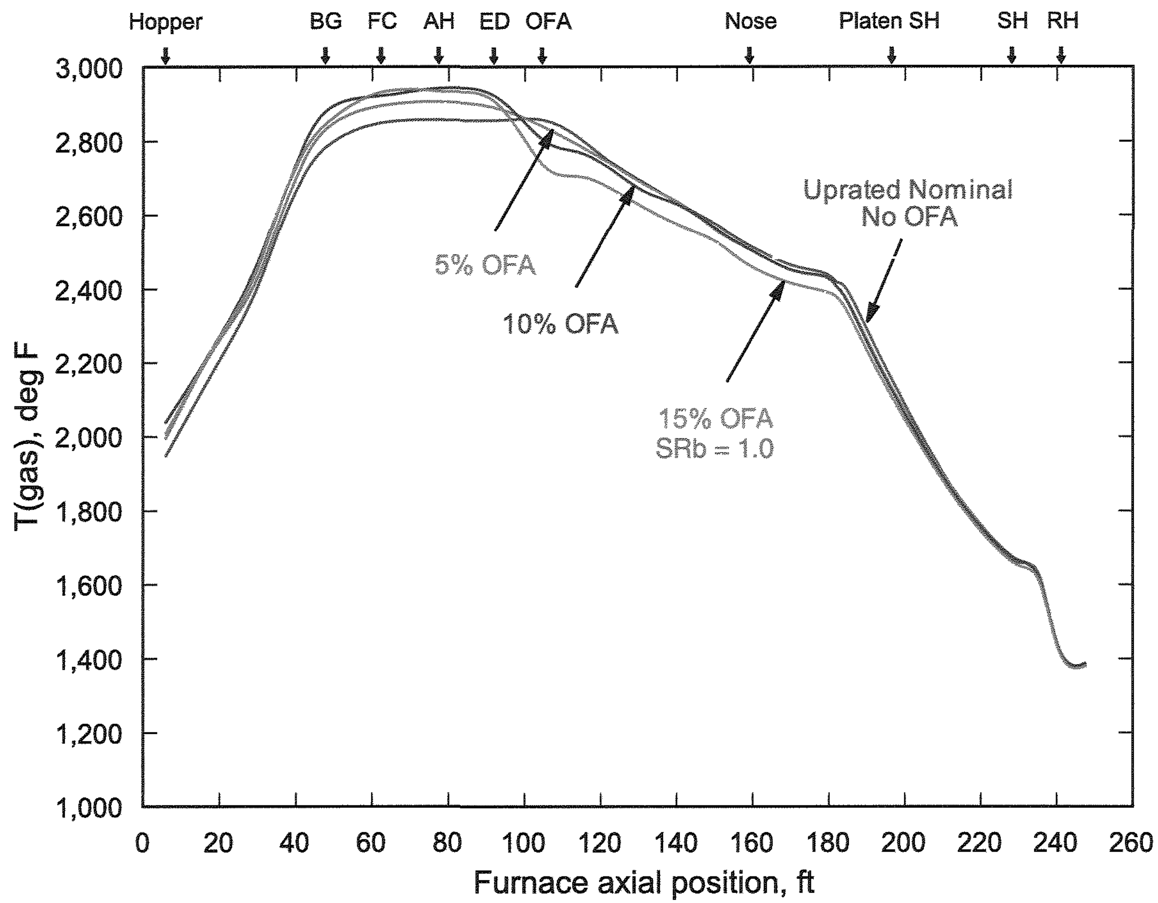
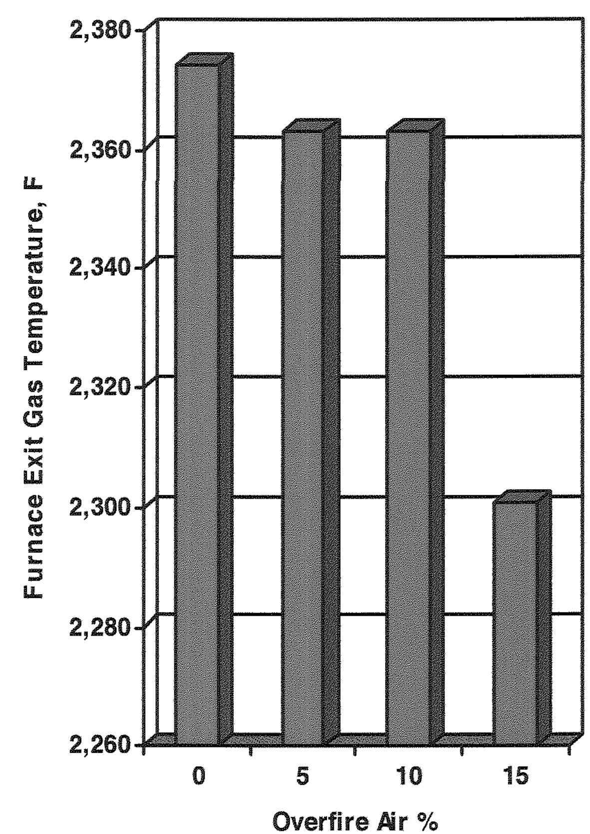
Boiler Performance Analysis

Uprated Nominal Load with OFA (950 MW)

Impact on mean gas temperature profile and FEGT





SRb = Stoichiometric Ratio in burner region

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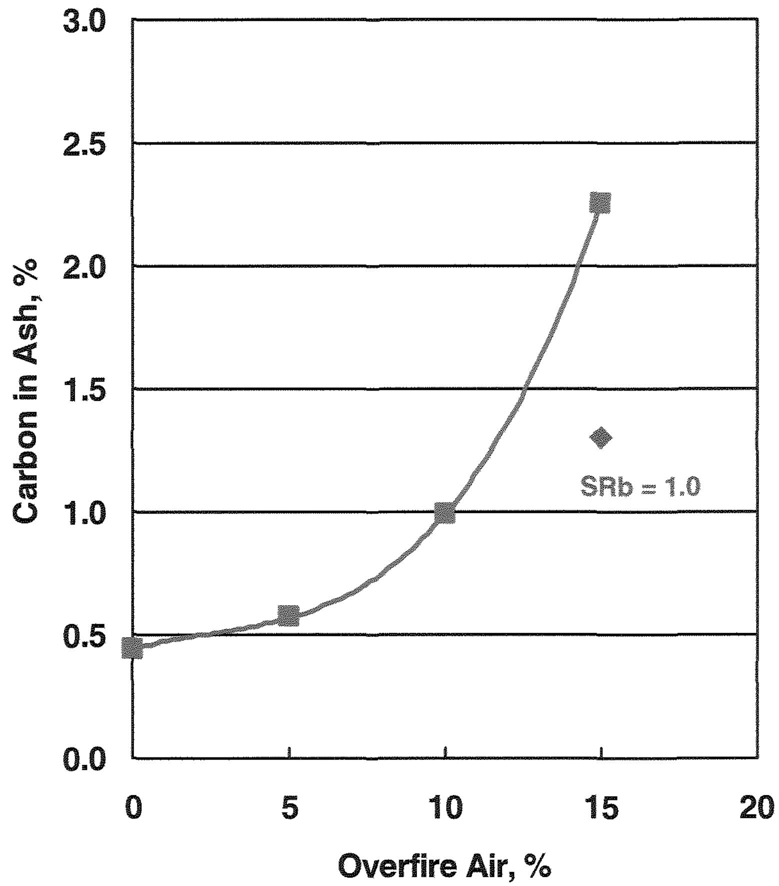
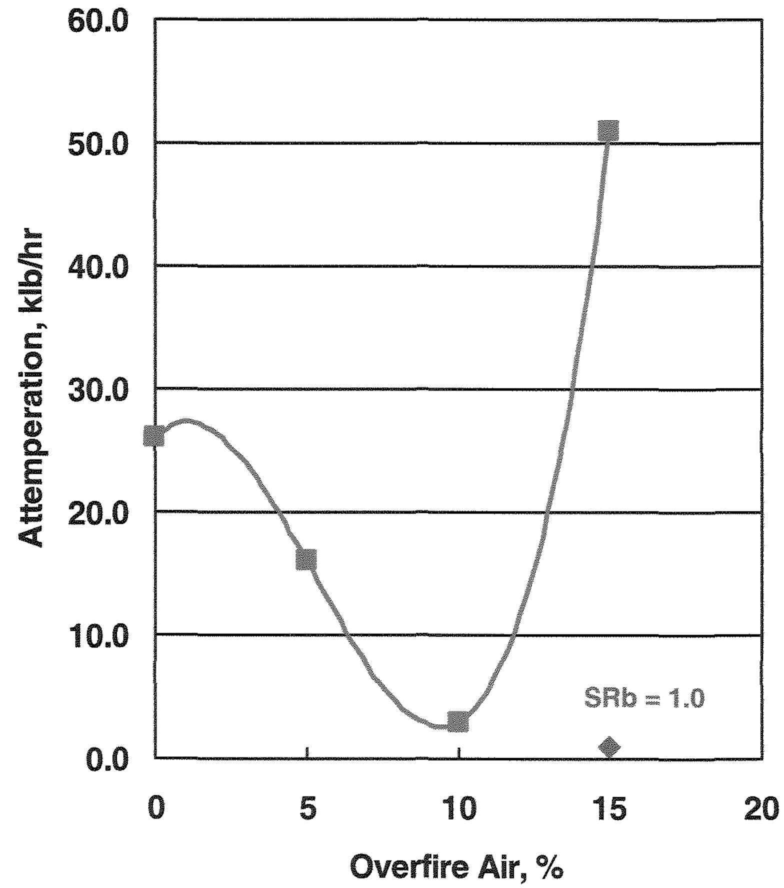
Boiler Performance Analysis

Uprated Nominal Load with OFA (950 MW)

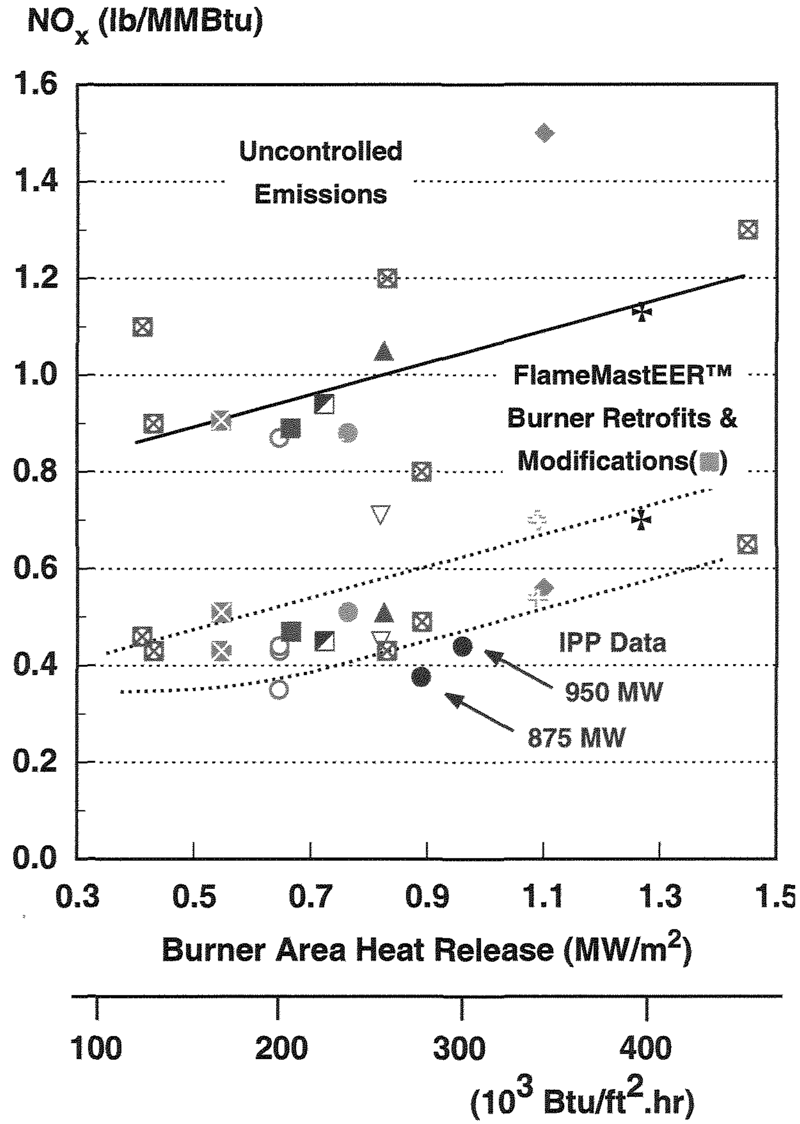
Impact on LOI & main steam attemperation





SRb = Stoichiometric Ratio in burner region

Emissions Performance Analysis



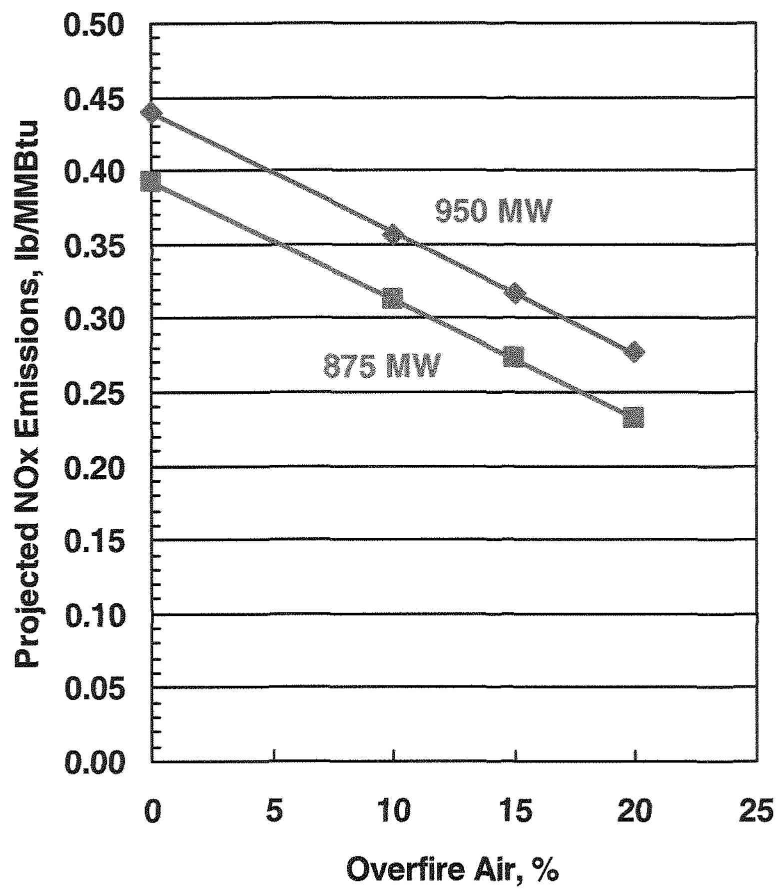
- Comparison of uncontrolled and retrofit low-NO_x burner emissions performance.
- Burner Area Heat Release (BAHR) used to correlate impact of furnace design on NO_x emissions.
- Overall performance depends on boiler design, retrofit flexibility, and fuel characteristics.
- IPP data fit within expected performance range.

g

Emissions Performance Analysis

Projected NOx Emissions with OFA

Comparison of original nominal and uprated nominal loads



OFA capable of reaching original emissions levels

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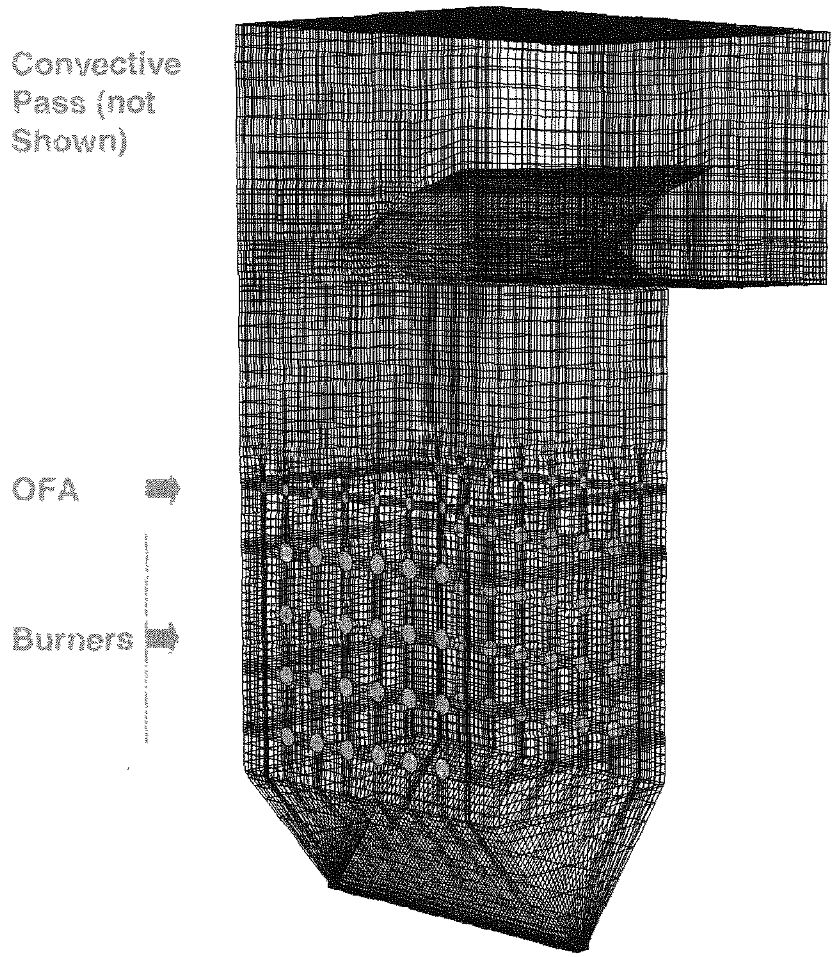
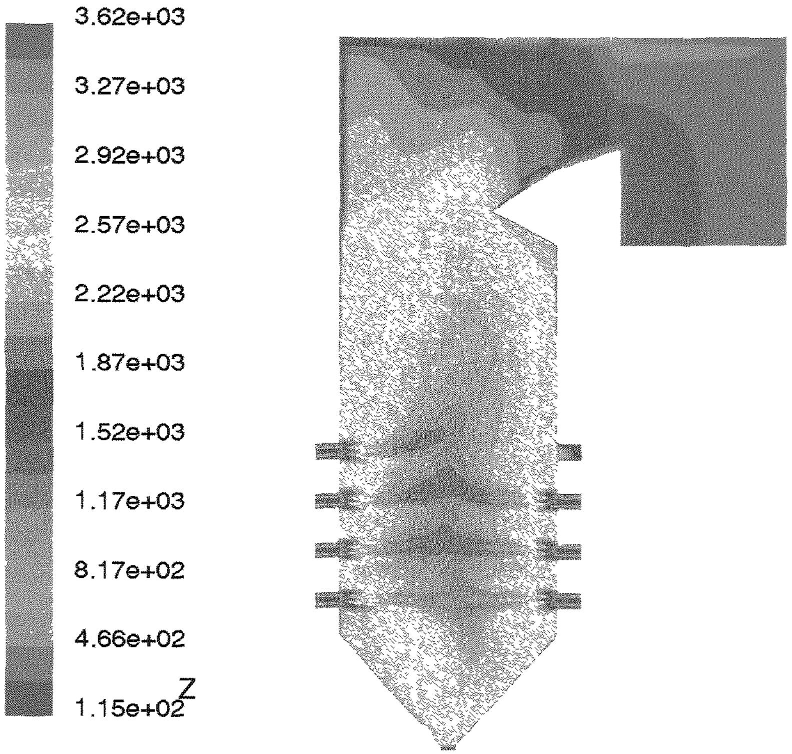
OFA Mixing Analysis

Computational Fluids Dynamics (CFD) Model



Cells ~ 350

Predicted Temperature Profile (Uprated nominal)



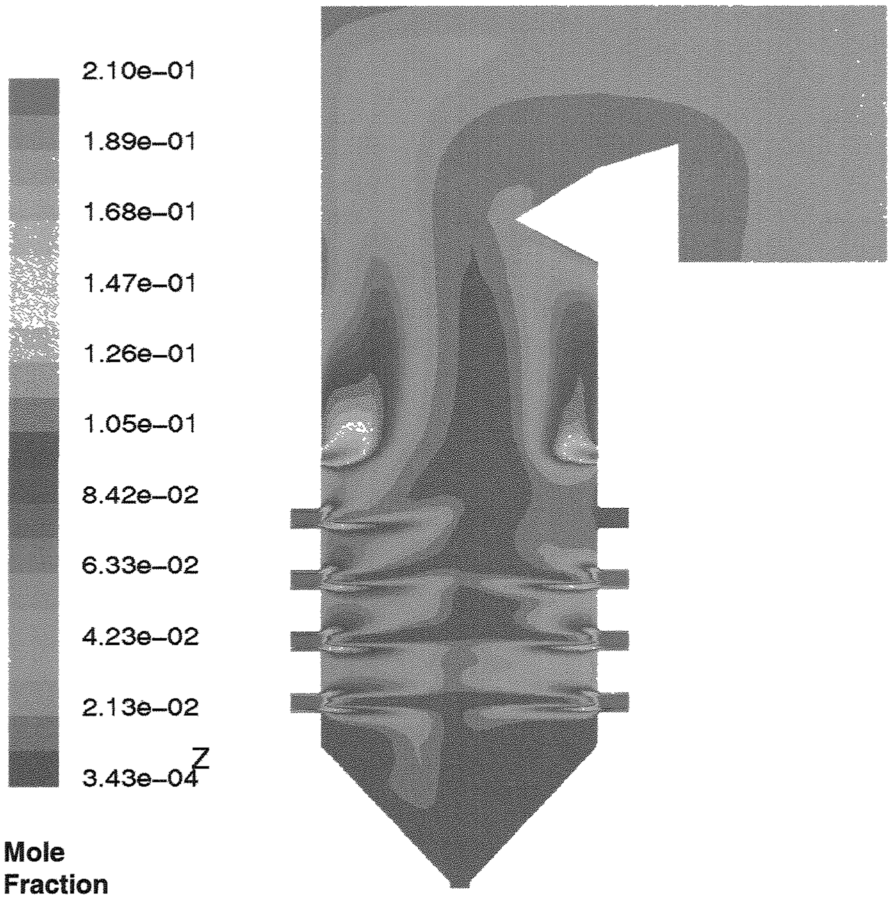
T (deg. F)

IP7_037204

OFA Mixing Analysis

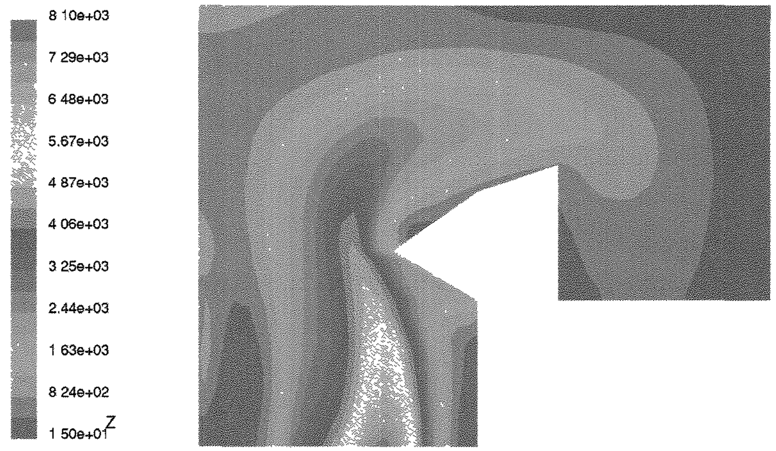
Uprated Nominal Load with 10% OFA

Predicted Oxygen Profile

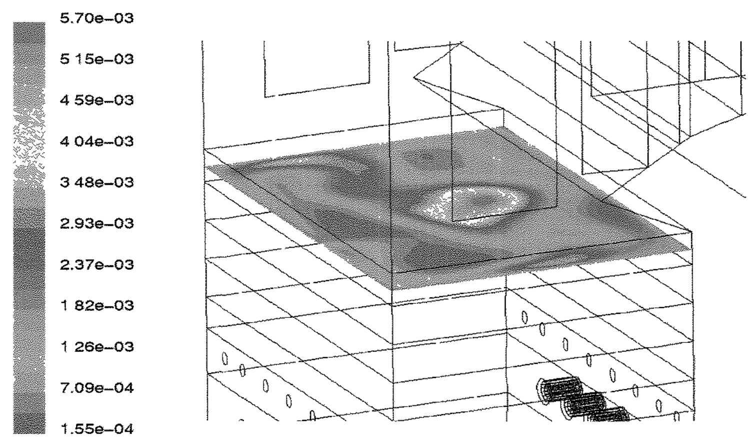


Mole Fraction

Predicted CO Profiles



ppm



Mole Fraction

IP7_037205

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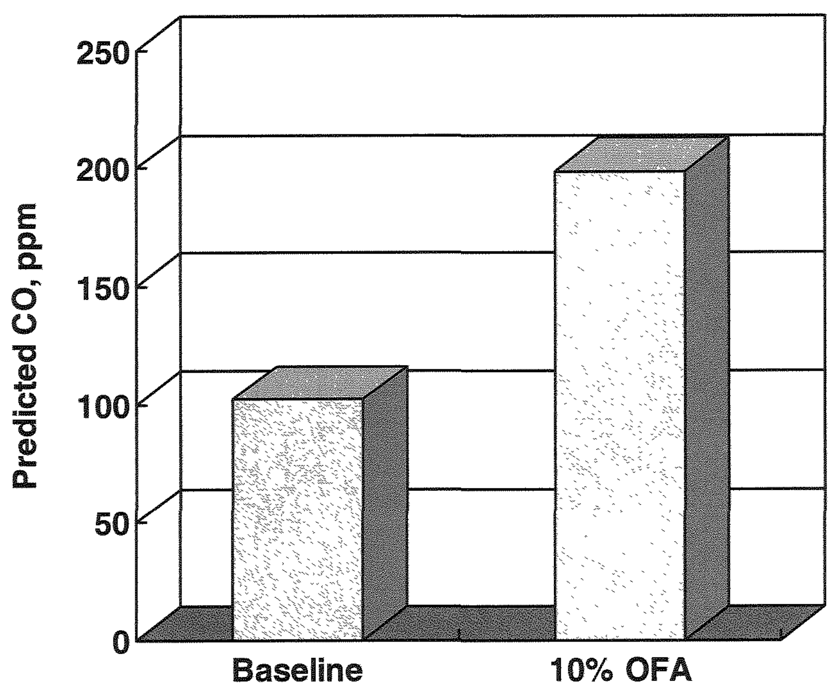
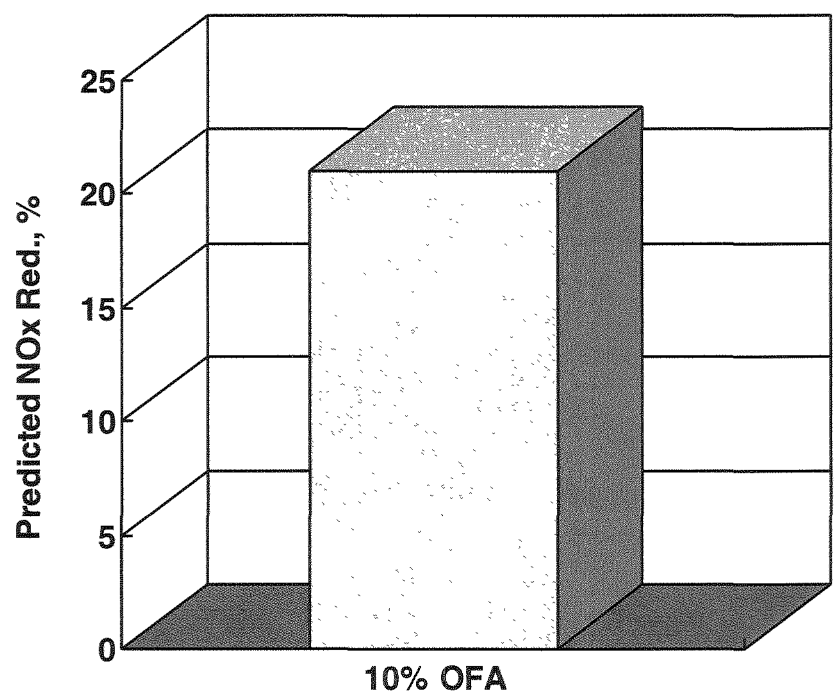
OFA Mixing Analysis

Uprated Nominal Load with 10% OFA

Impact of OFA on emissions predicted by CFD model





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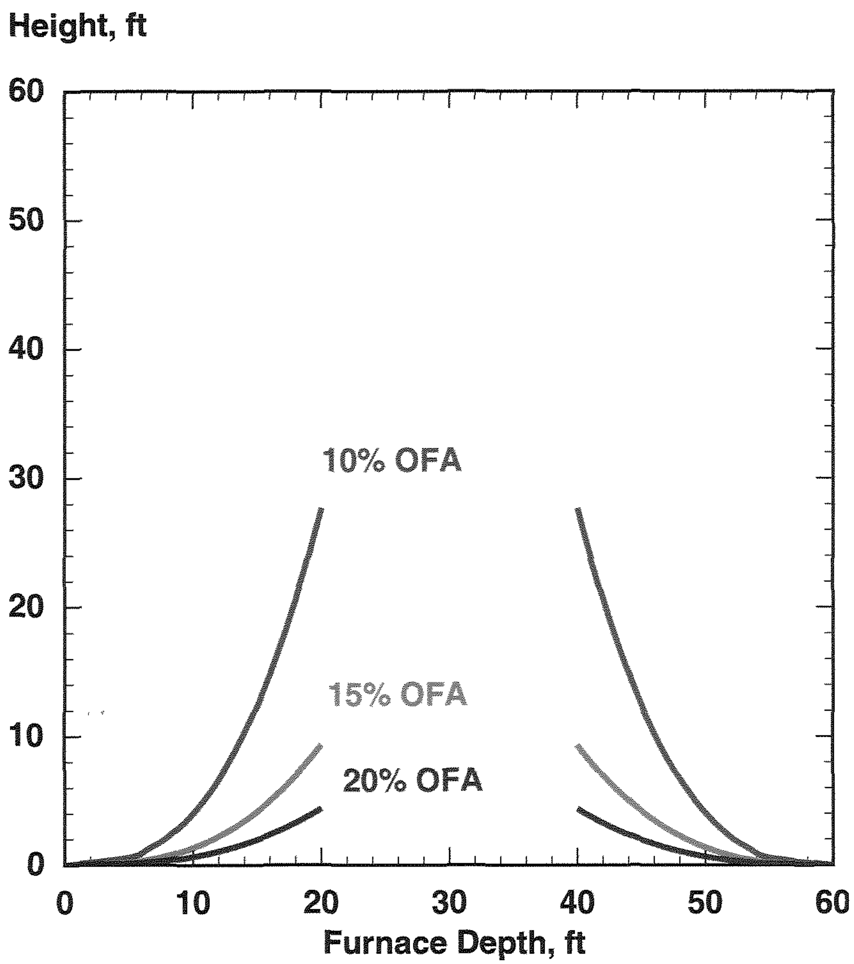
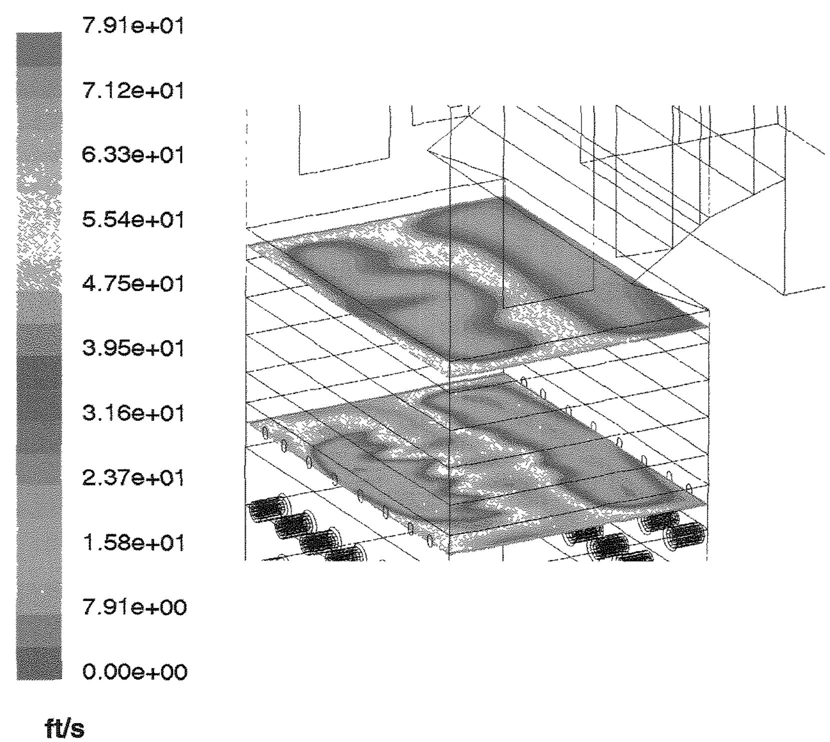
OFA Mixing Analysis

Uprated Nominal Load

Jet Penetration into Uniform Crossflow



Predicted Velocity Profiles



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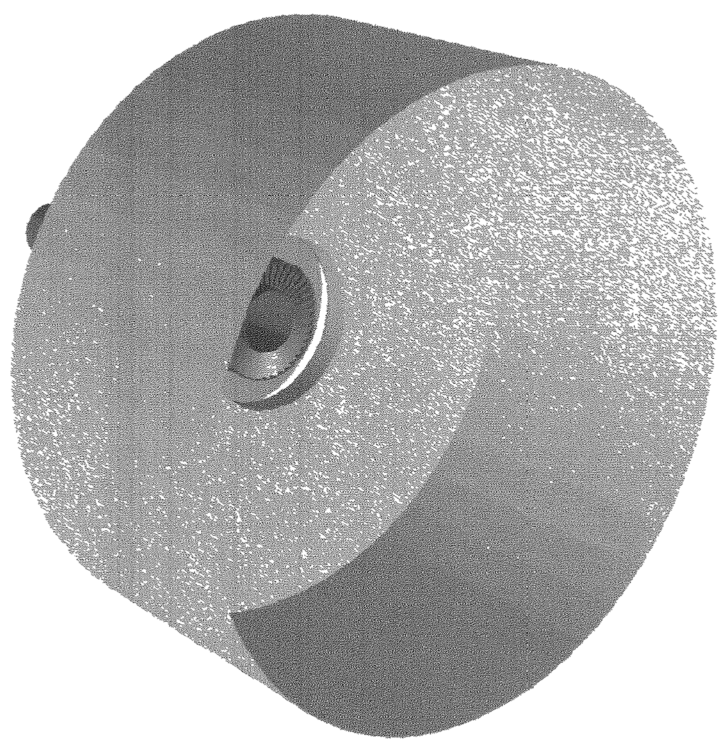
Metal Temperature Analysis

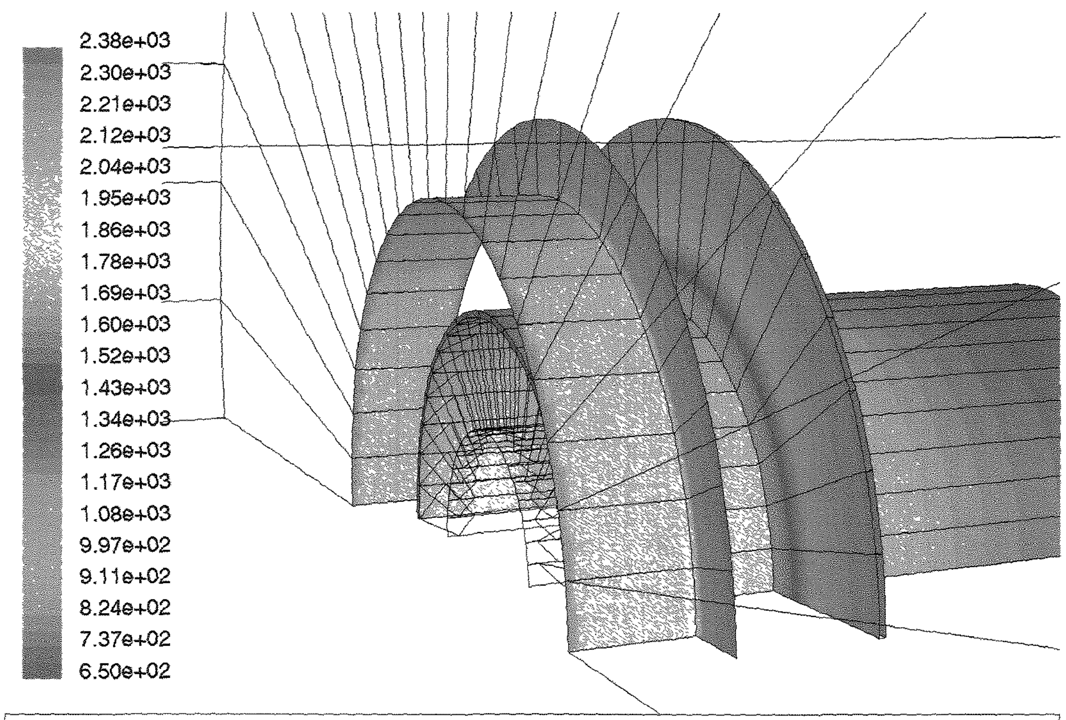
Computational Fluids Dynamics (CFD) Model

Analysis to be completed pending verification of B.C.

Model Geometry



Predicted Temperature Profiles



Contours of Static Temperature (f)
Jan 31, 2003
FLUENT 6.0 (3d, segregated, ske)

IP7_037208

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Conclusions

- **Overfire Air**
  - Increases carbon loss (10% OFA ~ 2x)
  - Increases CO emissions (10% OFA ~ 2x)
  - Reduces NO_X emissions (10% OFA ~ 20%)
  - Reduces main steam attemperation rates (for $SR_b > 1.0$)
  - Requires reduction in furnace heat absorption (i.e., more fouling) to maintain steam temperatures.
  - Mixing of proposed design at low OFA rates limited by low jet velocities and nonuniformities in flow field.
- **Platen Modification**
  - Increases main steam attemperation rates, particularly with OFA operation.
  - Maintains overall boiler performance.

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GE Power Systems

NOx Performance Analysis of the Upgraded IGS Unit 1&2 Steam Generators

4 February 2003

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Presentation Outline

- Introduction
- Background
- Performance Analysis
- Conclusions

IP7_037211

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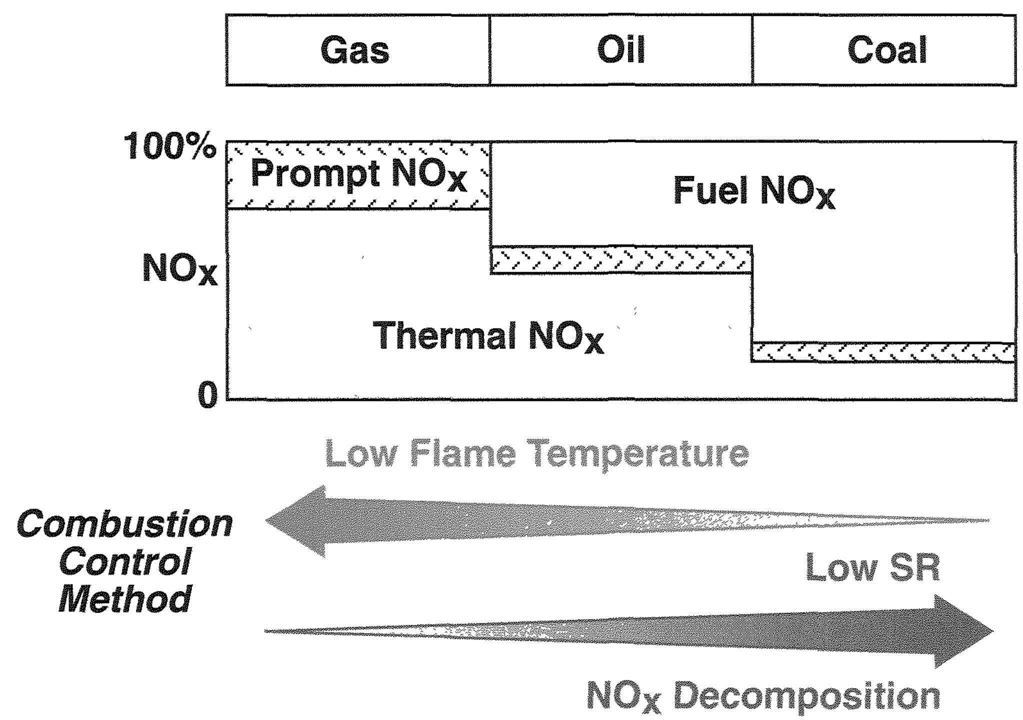
Introduction

- **Objectives of Performance Analysis**
  - Use results of modeling to develop process model for prediction of boiler NO_X emissions
  - Evaluate impacts of OFA operation on NO_X emissions

NO_x Emissions and Control

Impact of Fuel Type on Source of NO_x



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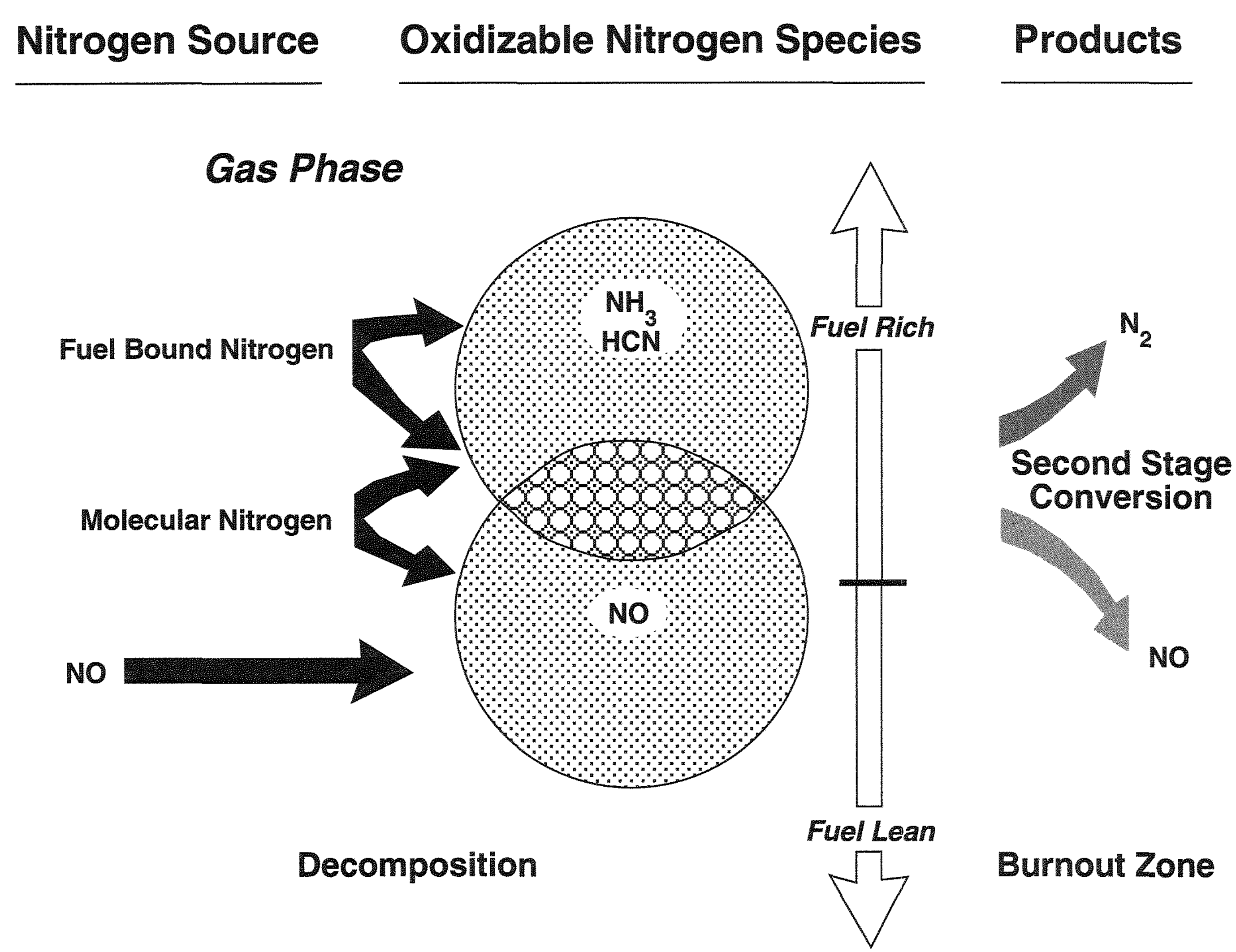
Controlling Fuel N Conversion



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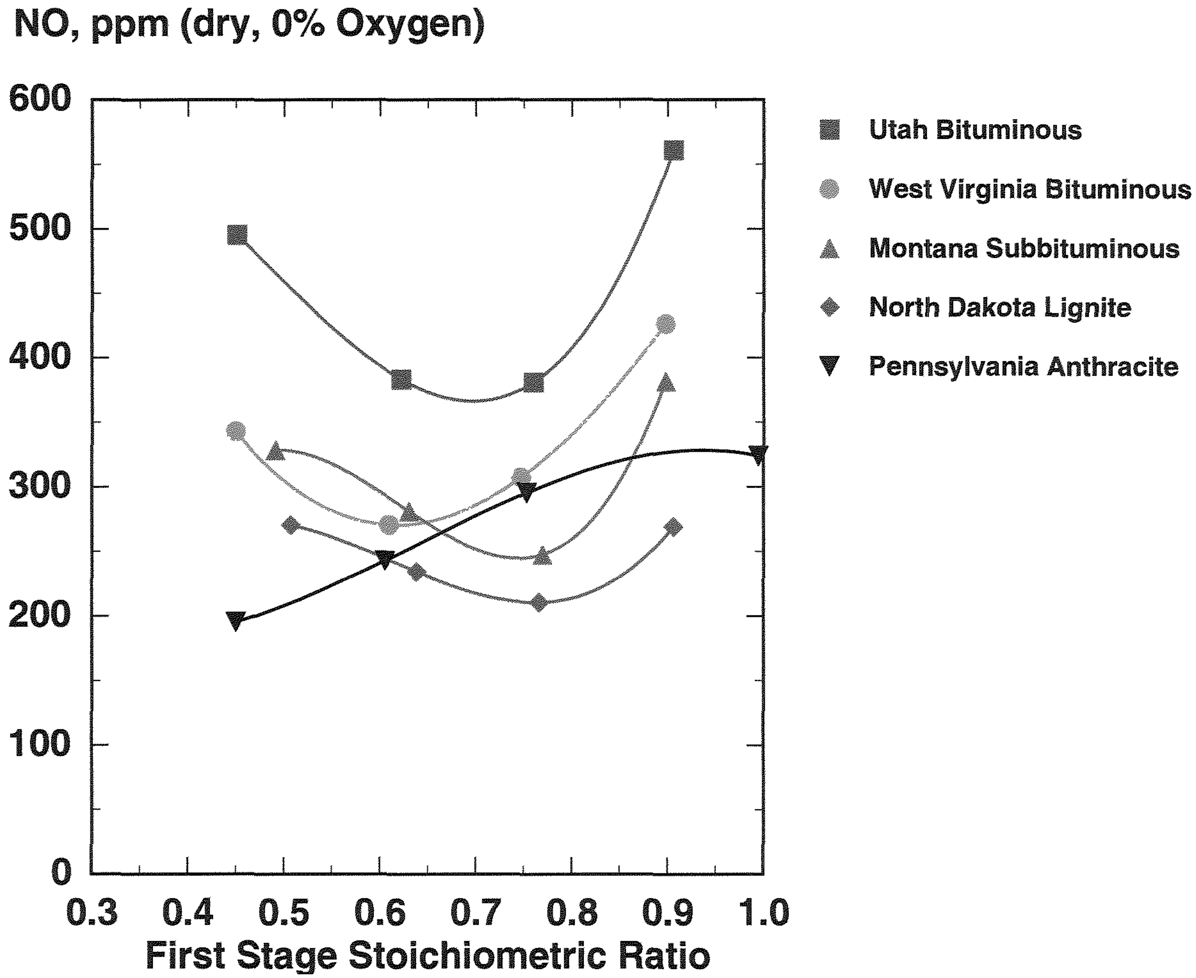
Controlling Fuel N Conversion

Impact of Staging



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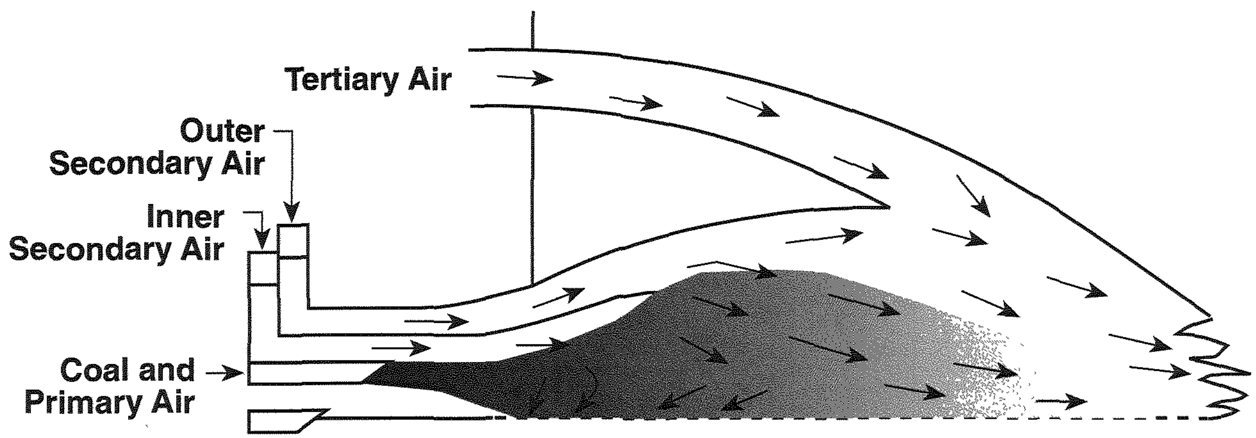
Low-NOx Burner Concepts

Internally Staged

Dual register type burner



Externally Staged

Distributed mixing burner

Overfire Air (OFA) increases staging resulting in improved performance

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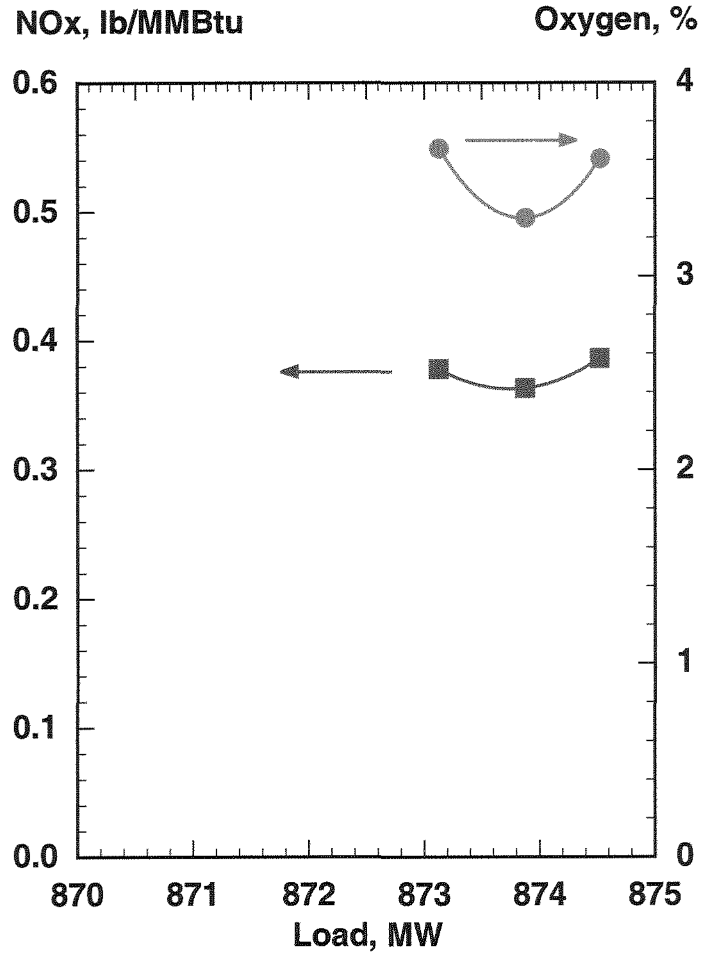
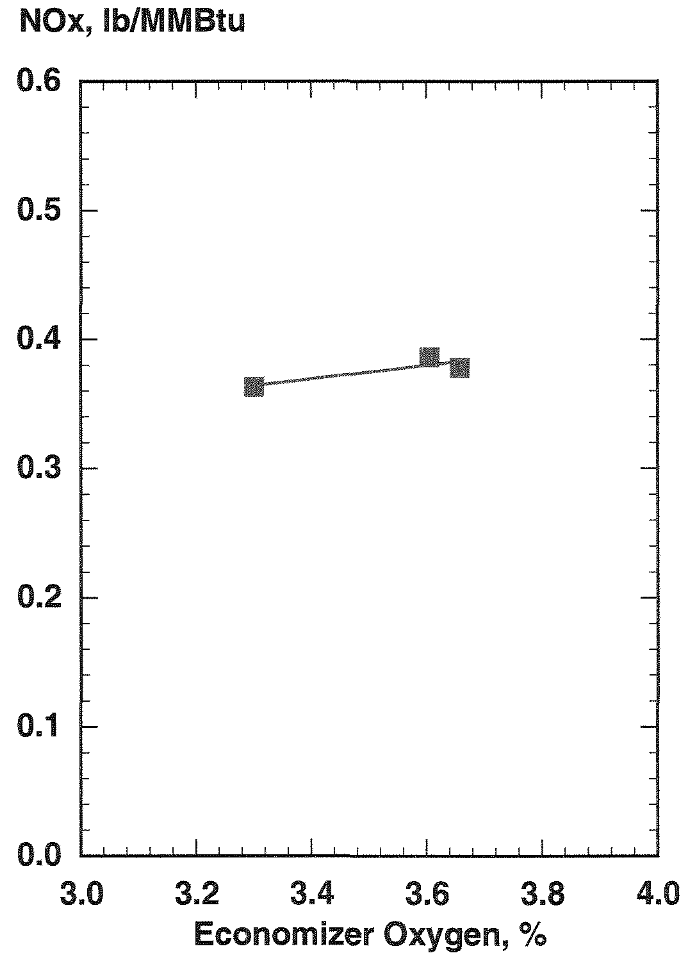
Emissions Data - Unit 1

Original Nominal (Dec. 2002)





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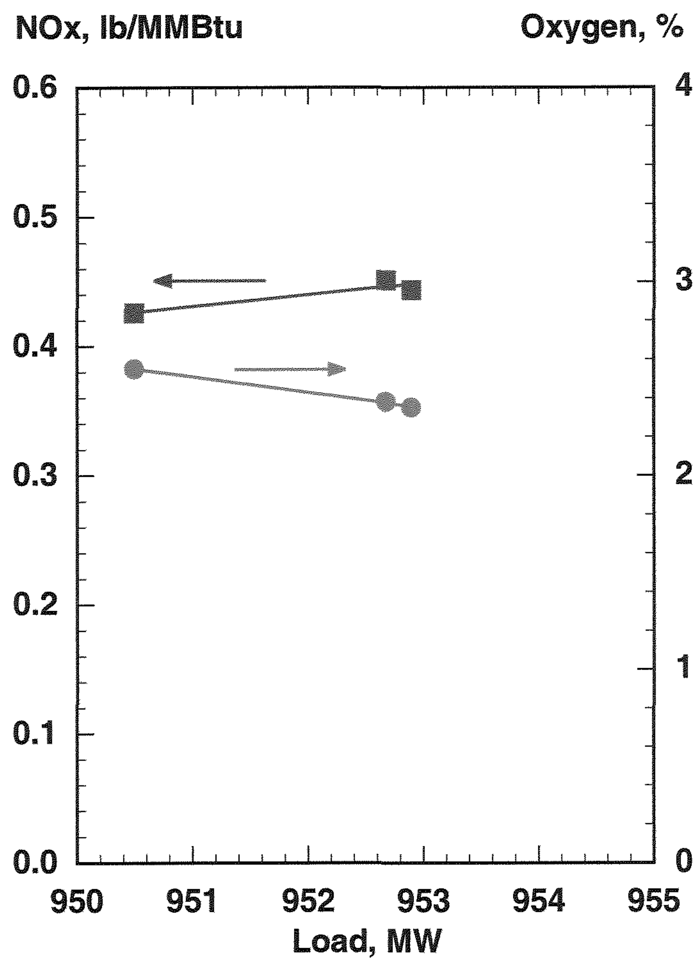
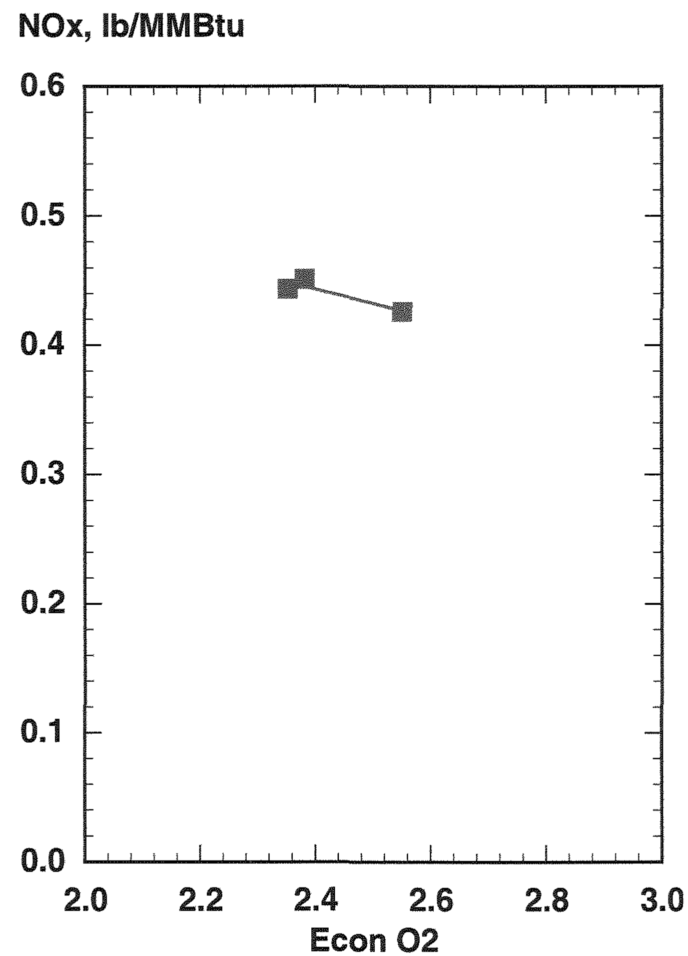
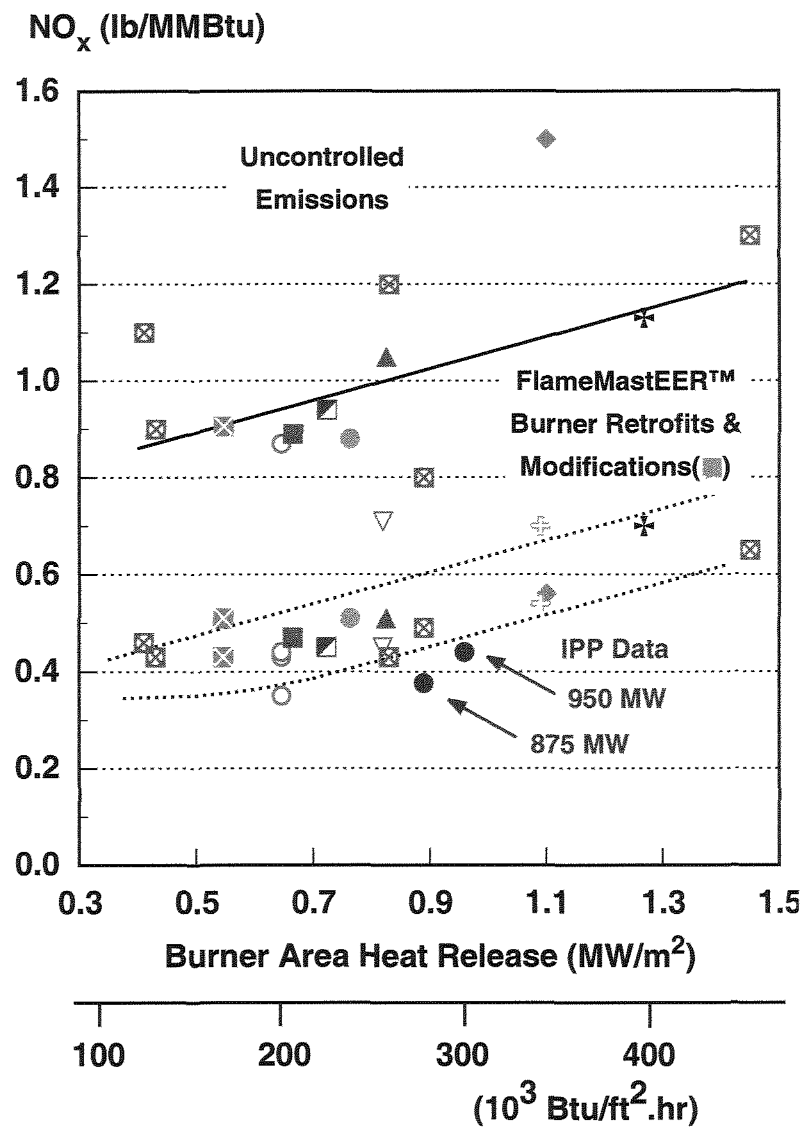
Emissions Data - Unit 2

Uprated Nominal (May 2002)





Performance Analysis



- Comparison of uncontrolled and retrofit low-NO_x burner emissions performance.
- Burner Area Heat Release (BAHR) used to correlate impact of furnace design on NO_x emissions.
- Overall performance depends on boiler design, retrofit flexibility, and fuel characteristics.
- IPP data fit within expected performance range.

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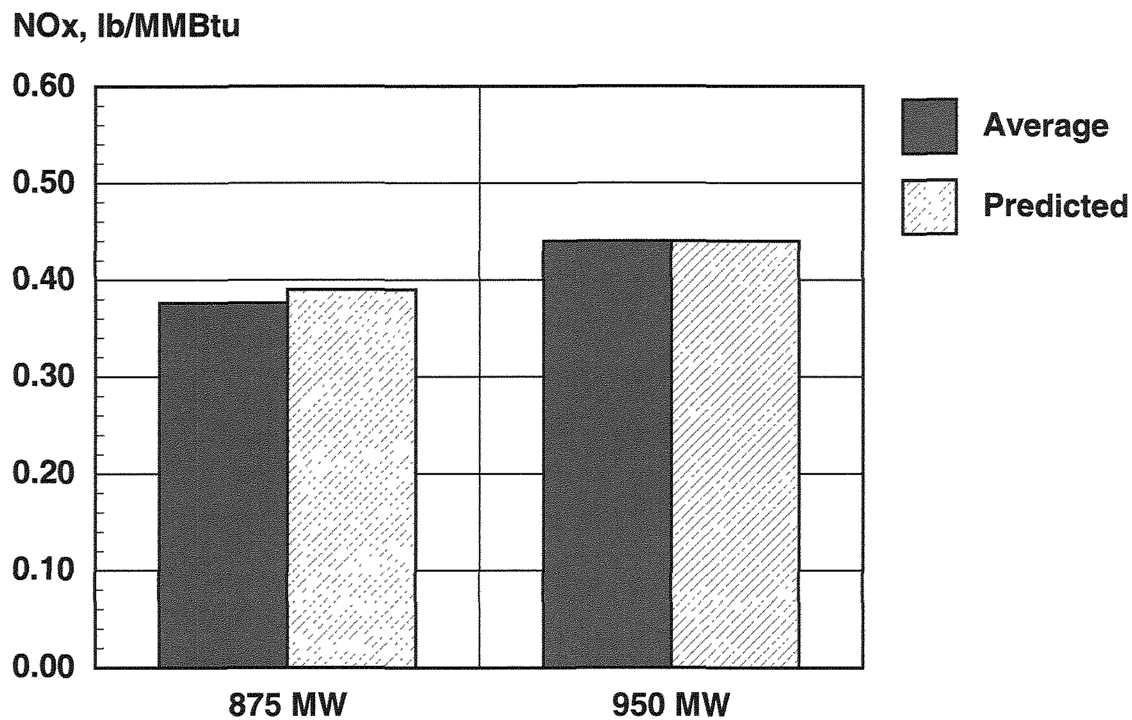
Performance Analysis

- **Comparison of actual and predicted emissions using low-NO_X burner process model**
  - Predictions based upon Fuel A
  - Good comparison between predicted and actual data



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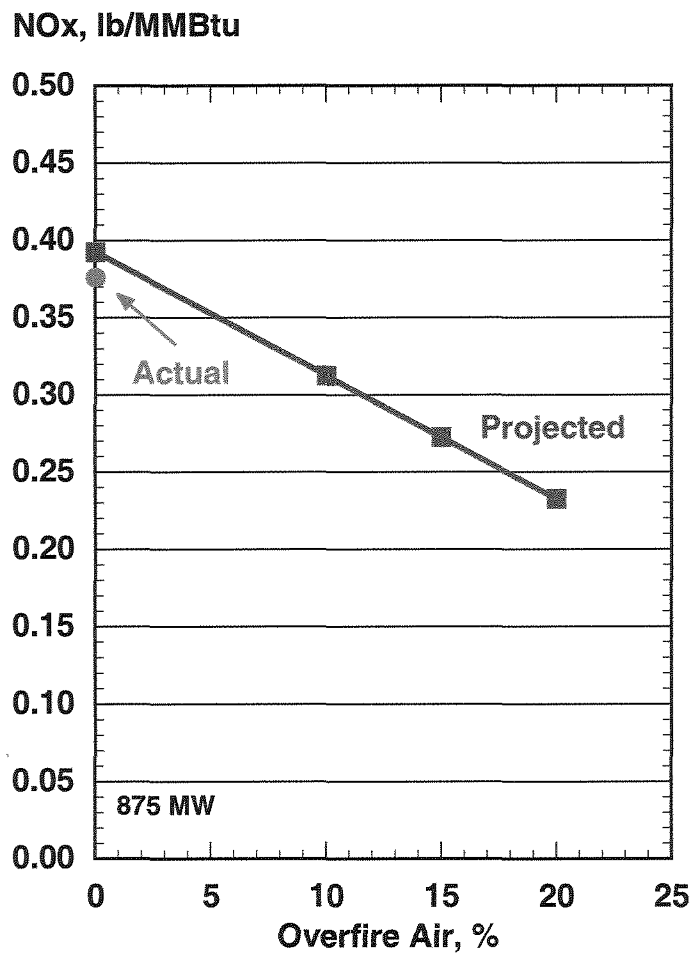
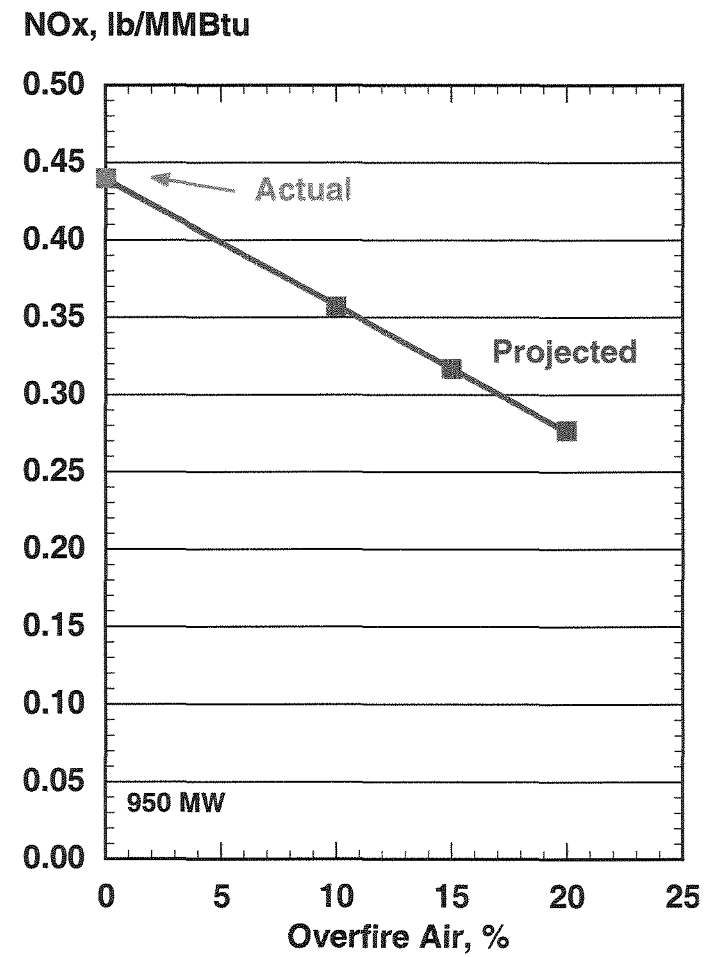
g Projected NOx Emissions

Impact of Overfire Air





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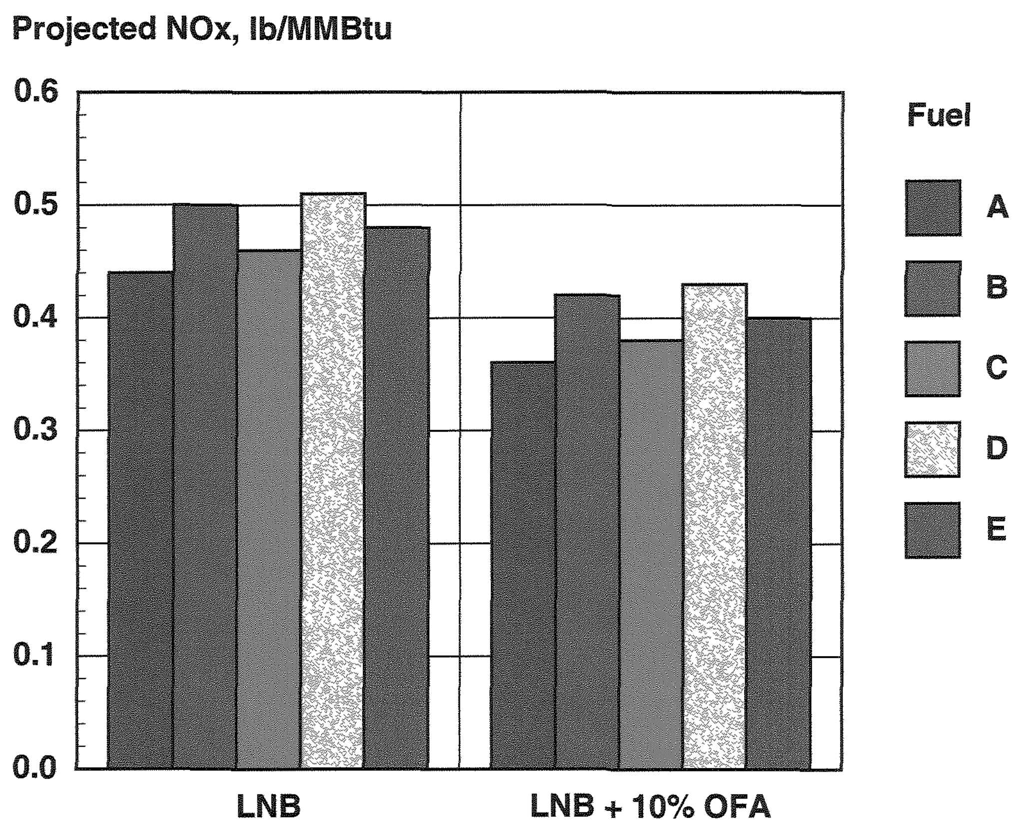
Projected NOx Emissions

Impact of Fuels Fired



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Conclusions

- Current boiler NO_X emissions in line with expectation for low-NO_X burners, boiler geometry, and fuels fired.
- Overfire air should be capable of reducing NO_X emissions to pre-upgrade levels.
- Primary constraints on OFA application will be increase in CO emissions and carbon loss.

Energy
SERVICES

Intermountain Power Services Corp.

Computer Modeling of the Upgraded IGS Unit 1 & 2 Steam Generators

Contract No. 3861

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February 2003

GE Energy Services

Table of Contents

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Table of Contents
(Continued)

List of Figures

List of Figures (Continued)

List of Tables

List of Tables (Continued)

List of Tables
(Continued)

Executive Summary

Intermountain Power Service Corporation (IPSC) is planning to modify the steam generators at the Intermountain Generating Station (IGS) in Delta, Utah. IPSC has upgraded the steam turbines at the plant requiring the boilers operate a higher steam generation rates. The planned upgrades to the steam generators include: (1) adding twelve feet extensions to the platen superheater loops, (2) if necessary, adding sootblowing enhancements to reduce fouling, and (3) retrofitting the units with an overfire air (OFA) system to reduce NO_X emissions.

GE EER has developed a boiler thermal model, a boiler computational fluid dynamics (CFD) model, and a burner CFD model to independently evaluate the impacts that the Intermountain Generating Station Units 1 and 2 furnace upgrades will have on boiler performance, gas emissions, and burner and tube metal temperatures. The computer models, in conjunction with other GE EER process engineering tools and personnel experience, were used to determine NO_X reduction with overfire air for five different fuel types provided by IPSC.

The boiler thermal model has been used to examine the impacts that OFA, excess air, and the addition of platen surface area have on boiler performance for uprated nominal conditions and reduced load conditions. The effect of different fuels on uprated nominal load performance with additional platen superheater area has also been evaluated. The model was calibrated with field data at both uprated MCR and original nominal load conditions (875 MW).

The results show that relative to the uprated nominal load conditions, operating with OFA is expected to increase carbon in ash and reduce main steam attemperation. Increased furnace fouling is necessary to maintain steam temperatures and attemperation rates. The overall impacts of OFA operation on boiler performance are minimal.

The platen modification increases main steam attemperation rates, even with OFA operation. Overall boiler performance could be also maintained with the platen upgrade. Boiler performance can be maintained for the range of fuels burned, provided that furnace heat absorption can be controlled to accommodate furnace characteristics. Boiler performance can

also be maintained with increased excess air, but attemperation rates are projected to increase. The case studies with additional excess air, reduced loads, and different fuels suggest that boiler efficiency does not reduce significantly. Running with the lower burner rows out of service is recommended for reduced load operating conditions. Fuel E shows a significant increase in carbon in ash during OFA operating conditions, suggesting that values may exceed 2 percent when running at OFA levels above 10 percent total air. The boiler thermal model also predicts that both OFA and platen modifications do not cause any significant changes in exchanger and waterwall tube metal temperatures relative to baseline operation.

The results of the furnace CFD model indicate that the furnace flow field is non-uniform, but typical of opposed wall-fired boilers. Upgrading the platen exchanger by adding additional surface area is expected to have a minor impact on the gas-side performance parameters evaluated, such as CO distribution. At 10 percent OFA, the OFA jets do not achieve deep penetration across the furnace cross section. Operation with the 1/3 damper closed results in a small improvement in OFA penetration. OFA mixing and CO oxidation continues as the flue gas enters the backpass; however, CO emissions are projected to nearly double with 10 percent OFA operation. Biasing flow in the OFA injectors may help improve jet penetration and mixing effectiveness. Because the model shows that the concentration characteristics (e.g. CO) of the boiler map very well from the OFA to the backpass regions, OFA flow biasing can probably be adjusted using CO grid measurements at the economizer exit.

The results of the burner CFD model indicate that the rear plate wall temperature distribution in the outer secondary airflow duct does not increase to dangerous levels during 10 percent OFA operating conditions when burners are either in service or out of service. The primary reason that the burner-out-of-service operating scenario does not generate any additional thermal problems is because IPSC adjusts the airflow rate in the out-of-service burner to accommodate any changes in heating rates. IPSC has informed us that the flow may increase or decrease relative to in-service operation depending on which burner row is out-of-service. The model predicts that additional heating due to higher source temperatures under OFA conditions does not require a any increase in cooling airflow relative to that for baseline conditions. Therefore, maintaining burner wall temperatures below the current threshold values during OFA operating conditions should be readily handled with the current burner damper and monitoring systems.

A process model was also developed to project the impacts of overfire air on NO_X emissions for uprated nominal flow conditions (950 MW). Based upon the characteristics of Fuel A, the process model predicted a NO_X emissions level of 0.39 lb/MMBtu for an operating load of 875 MW and of 0.44 lb/MMBtu for an operating load of 950 MW. The predictions were in good agreement with the baseline data. At the uprated nominal load, operation with 7% overfire air is expected to reduce NO_X emissions levels to the current level of 0.38 lb/MMBtu. Operation with 10% overfire air is projected to reduce NO_X emissions to a level of approximately 0.36 lb/MMBtu. NO_X emissions predicted by the FLUENT fuel NO_X sub-model and the boiler CFD model produced similar results.

The projected impacts of the different fuels fired on NO_X emissions with and without overfire air were also evaluated. In comparison to Fuel A, the combustion of Fuels B-E is expected to result in higher NO_X emissions due to the differences in fuels characteristics. Therefore, it is expected that higher levels of overfire air will be required when firing these fuels in order to minimize their impact on the unit NO_X emissions.

1.0 Introduction

Intermountain Power Service Corporation (IPSC) is planning to modify the steam generators at the Intermountain Generating Station (IGS) in Delta, Utah. IPSC has upgraded the steam turbines at the plant requiring the boilers operate a higher steam generation rates. The planned upgrades to the steam generators include: (1) adding twelve feet extensions to the platen superheater loops, (2) if necessary, adding sootblowing enhancements to reduce fouling, and (3) retrofitting the units with an overfire air (OFA) system to reduce NO_X emissions.

ISG Units 1 and 2 are opposed wall-fired boilers that fire western bituminous coal. With turbine and boiler upgrades, the boilers operate at 950 MW at uprated nominal load conditions (6.64 MM lb/hr stream flow rate). Six burners are arranged in each of four rows on both front and rear walls, totaling forty-eight burners. At nominal load conditions, the boilers operate with one burner row out of service depending on which mill is being serviced (one mill supplies each burner row). The boilers have both platen and finish superheaters in the upper furnace and a split backpass configuration with a primary reheater on one side of the backpass and a primary superheater/economizer series arrangement on the other side of the backpass. The steam flow rate, and superheater and reheater steam temperatures are controlled by adjusting the backpass flow split ratio and the waterwall/exchanger fouling characteristics using sootblowers.

An external contractor has designed an OFA system to provide the IGS steam generators with NO_X emissions control at uprated nominal operating conditions. The OFA system has elliptical-shaped injectors with the major axis in the vertical direction. Eight evenly spaced injectors will be mounted on both front and rear walls. A ninety-degree vertical bend has been placed in the OFA duct upstream of each injector. The flow immediately upstream of the bend can be partitioned by two flow dampers, one covering two-thirds of the duct cross-sectional area and the other covering the remaining one-third of the cross-sectional area. A turning vane has been placed in the bend to preserve any pre-conditioned flow characteristics as the flow passes through duct bend and into the injector outlet. The primary purpose of the dampers is to control the velocity head at the injector outlet, which impacts OFA mixing effectiveness and CO oxidation in the furnace.

The OFA system upgrade also includes adding platen exchanger surface area by extending the tubes at the base of the exchanger downward twelve additional feet. After the upgrade, the base of the platen exchanger will be about one foot above the tip of the furnace nose.

GE EER has been contracted by IPGS to develop a boiler thermal model, a boiler computational fluid dynamics (CFD) model, and a burner CFD model to independently evaluate the impacts that these furnace upgrades will have on boiler performance, gas emissions, and burner and tube metal temperatures. The modeling studies specifically address the following questions raised by IPGS regarding the upgrades:

- How does the OFA system affect boiler performance?
- How does the additional platen exchanger surface area affect boiler performance with and without OFA in service?
- How effectively does the OFA mix with the flue gas and oxidize CO?
- What impact does OFA have on the CO distribution and CO emissions relative to baseline conditions?
- What impact does fuel type/composition have on NO_X emissions and carbon-in-ash?
- How does OFA operation affect tube and burner metal temperatures?

To address boiler thermal performance issues and understand various operating scenarios with the OFA upgrade, GE EER has developed a boiler thermal model of the IGS Unit 2 boiler. Results from the thermal modeling study were also used to estimate exchanger and waterwall tube metal temperatures under uprated boiler conditions and help determine specific operating conditions for the furnace and burner CFD models. The furnace CFD model was developed, using FLUENT 6.0 software, to provide detailed predictions of the local gas temperatures and compositions in the furnace. The primary focus of this study was to predict the CO distribution in the furnace and the change in CO concentration during OFA operating conditions relative to baseline conditions. The CFD model was also used to evaluate how effectively the overfire air mixes with the flue gas, which has a significant impact CO oxidation and carbon in ash. A CFD model of one IGS burner was also constructed to specifically predict the impact of boiler upgrades on burner metal temperatures under OFA operating conditions. The computer models, in conjunction with other GE EER process engineering tools and personnel experience, were used to determine NO_X reduction with overfire air for five different fuel types provided by IPSC.

Section 2 of this report gives the results of the boiler thermal impact study for uprated nominal operating conditions with and without OFA and additional platen superheater area. Section 3 focuses on the furnace CFD and burner thermal CFD studies for OFA operating conditions with and without additional platen surface area. Section 4 discusses the NO_X impact analysis for OFA operating conditions and different fuel types. All of the model setup and calibration details, tube metal temperatures, and detailed tabulations of the thermal results can be found in Appendices 1 and 2.

2.0 Boiler Thermal Impact Study

A boiler thermal model for IGS Unit 2 has been developed to examine the impacts that overfire air, excess air, and the addition of platen surface area have on boiler performance for uprated nominal conditions and reduced load conditions. The effect of different fuels on uprated nominal load performance with additional platen superheater area has also been evaluated. The study specifically targets how uprated flow conditions with the upgrades described in Section 1 affect steam generation rates, main steam and reheat steam temperatures, carbon-in-ash predictions, and overall heat absorption distribution between the furnace and heat exchanger components.

Prior to conducting the parametric study, the boiler thermal model was set-up and calibrated using field data at uprated MCR conditions (Test 1 May 16, 2002). The fuel analyses, furnace geometry, and heat exchanger specifications were also provided by IPSC for model calibration. The details of model set-up and calibration at uprated MCR, uprated nominal (950 MW), and original full load (875 MW) conditions are provided in Appendix 1. A summary of the primary parameters for the baseline, overfire air, and reduced load case studies are given in Table 2-1. A detailed stepwise sequence of adjustments to the boiler leading to the final process set of conditions for each test case are also presented in Appendix 1. Table 2-2 provides a summary of the fuel analyses the five fuels considered in the fuels study. Fuel A was used in the baseline MCR calibration and for most of the OFA and platen upgrade case studies. The results of the thermal impact study were used to evaluate tube metal temperatures also discussed in Appendix 1. Only the final test conditions for each case study are presented in this section; a detailed discussion of the changes made to the boiler operating conditions to restore baseline thermal performance for each case study can be found in Appendix 1.

The following section discusses the impacts of overfire air on boiler performance at uprated nominal conditions. Section 2.2 addresses how additional platen superheater area affects boiler performance at baseline uprated nominal conditions with overfire air. The impacts of excess air on thermal performance with additional platen superheater area are discussed in Section 2.3. Case studies evaluating the effects of additional platen superheater area at reduced load conditions can be found in Section 2.4 and the fuels impact study at uprated nominal conditions

TABLE 2-1. THERMAL MODEL CASE STUDIES

Case No	Case Definition	% Overfire air	Stoichiometric Ratio Burners	OFA	Exit
1	MCR Baseline	0	1.14	1.14	1.14
2	Original Baseline (875MW)	0	1.20	1.20	1.20
3	Uprated Nominal Baseline	0	1.15	1.15	1.15
4	Uprated Nominal Baseline (with additional Platen SH area)	0	1.15	1.15	1.15
5	Uprated Nominal with OFA	5	1.09	1.15	1.15
6	Uprated Nominal with OFA	10	1.03	1.15	1.15
7	Uprated Nominal with OFA	15	0.97	1.15	1.15
8	Uprated Nominal with OFA	15	1.00	1.18	1.18
9	Uprated Nominal with OFA (with additional Platen SH area)	10	1.03	1.15	1.15
10	75% Uprated Nominal (with additional Platen SH area)	0	1.32	1.32	1.32
11	50% Uprated Nominal (with additional Platen SH area)	0	1.55	1.55	1.55
12	Uprated Nominal with 3% O_2 wet (with additional Platen SH area)	0	1.18	1.18	1.18
13	Uprated Nominal Baseline (with additional Platen SH area) for				
a	Fuel B	0	1.15	1.15	1.15
b	Fuel C	0	1.15	1.15	1.15
c	Fuel D	0	1.15	1.15	1.15
d	Fuel E	0	1.15	1.15	1.15
14	Uprated Nominal with OFA - Fuel E (with additional Platen SH area)	10	1.03	1.15	1.15

* Based on 100 percent heat input to the burners

TABLE 2-2. FUEL ANALYSES USED IN THE THERMAL MODEL

	IGS Unit 2				
	Fuel A Baseline	Fuel B	Fuel C	Fuel D	Fuel E
Proximate Analysis (mass, % wet)					
Fixed Carbon	48.41	48.10	48.04	46.64	52.24
Volatiles	34.59	33.63	37.67	33.85	34.53
Moisture	6.32	6.06	6.98	8.71	5.46
Ash	10.68	12.21	7.31	10.80	7.77
Total	100.00	100.00	100.00	100.00	100.00
Ultimate Analysis (mass, % dry)					
C	71.10	70.00	74.54	70.66	74.80
H	5.01	5.57	5.72	5.73	5.55
N	1.48	1.81	1.77	1.85	1.79
O	10.33	8.92	9.50	9.39	8.45
S	0.68	0.70	0.61	0.54	1.20
Ash	11.40	13.00	7.86	11.83	8.21
Total	100.00	100.00	100.00	100.00	100.00
Higher Heating Value (Btu/lb, wet)	11,927	11,751	12,597	11,321	12,883

with additional platen superheater area is presented in Section 2.5. The main conclusions from the thermal impact analysis are summarized in Section 2.6.

2.1 Overfire Air Operation (Uprated Nominal Load)

The impact of overfire air on boiler performance has been examined at uprated full load conditions. The amount of air injected into the boiler in the OFA ports will have an impact on overall NO_x emissions. The boiler thermal model was run at 5, 10 and 15 percent OFA conditions without the platen superheater upgrade. Operating the burners at a lower burner stoichiometric ratio reduces NO_x because less oxygen is available to react with both free and fuel-bound nitrogen in the primary burner region of the boiler. All three OFA conditions were run with 2.5 percent $O_{2,wet}$ at the economizer exit, corresponding to an overall stoichiometric ratio of 1.15 and burner stoichiometric ratos of 1.09, 1.03, and 0.97, respectively. One additional test case was run with 15 percent OFA at 2.95 percent $O_{2,wet}$ at the economizer exit, yielding overall and burner stoichiometric ratio of 1.18 and 1.0. In all test cases, the baseline fuel distribution between the burner rows was maintained with Mill D kept out of service. In general, to recover uprated nominal operating conditions for the different case studies, adjustments were made to boiler waterwall and exchanger fouling, and split backpass mass flow ratio. Adjustments to waterwall fouling are reported as a relative waterwall conductance, which is the ratio of the waterwall conductance at the specified conditions to that at uprated nominal conditions. The details of these adjustments are given in Appendix 1.

Figure 2-1 provides the gas temperature distributions for baseline and OFA cases. During OFA conditions, the gas temperatures are higher in the burner region than those for baseline burner conditions because sensible gas heating is less in the burner region of the boiler where most of the heat is released. Injection of colder air at the OFA port lowers the gas temperatures, which remain below baseline temperatures downstream resulting in a lower FEGT. Eventually, the gas temperatures recover to baseline conditions near the backpass entrance. The magnitude of these trends is enhanced as the percent overfire air increases. Note that the gas temperature for the 15 percent OFA at a burner stoichiometric ratio of 0.97 recovers faster than the other OFA

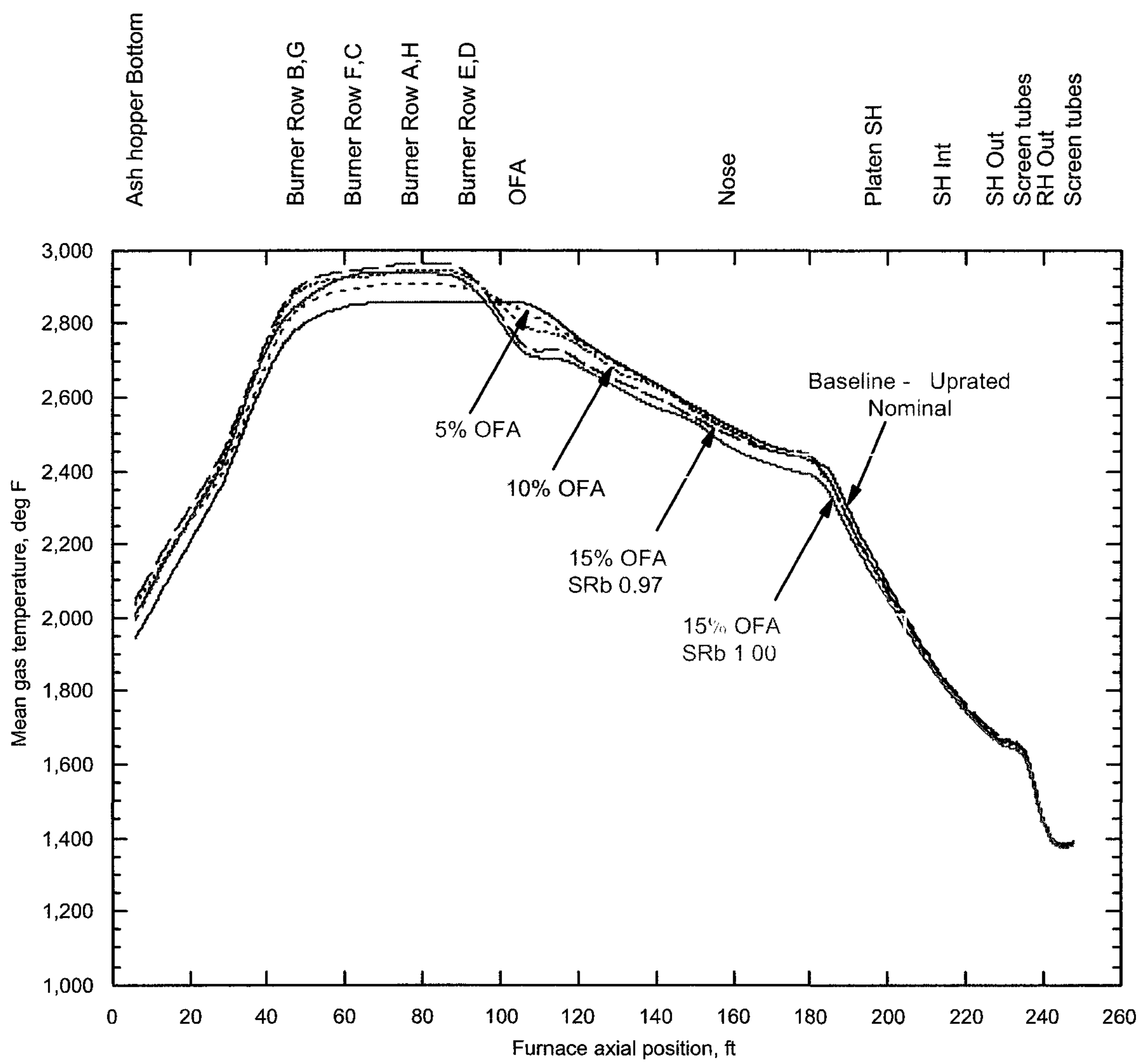

Figure 2-1. Predicted bulk furnace gas temperatures for uprated nominal Baseline and Overfire air conditions

cases with burner stoichiometric ratios greater than or equal to one. This occurs because the heat release curve is shifted upward when the burner region operates at fuel rich conditions.

Table 2-3 gives a comparison of key thermal performance results for the different OFA test cases. As the percent OFA increases, there is less sensible heating of the gas in the burner region, which causes increases in furnace heat release and waterwall heat absorption. Additional waterwall fouling is used to restore the uprated baseline steam flow rate. For OFA conditions, even with the baseline steam generation rate restored, the gas temperatures at the platen exchanger entrance are lower than those for baseline conditions. This lowers temperature driving force in the convective region and consequently reduces the attemperation rate. These trends, shown graphically in Figure 2-2(a), apply when the burners operate above a stoichiometric ratio of one (fuel lean conditions). Fuel lean conditions apply to the 0, 5, and 10 percent OFA cases, and the 15 percent OFA case with a burner stoichiometric ratio (SR_b) of 1.0. For fuel rich conditions in the burner region, 15 percent OFA with $SR_b = 0.97$, heat is released higher in the furnace causing the gas temperature to recover faster. This increases the heat duty to the exchangers and causes the main steam attemperation rate to increase.

Table 2-3 and Figure 2-2(b) show that the carbon in ash increases as the percent OFA increases. This occurs because as the percent OFA increases, less oxygen is available in the burner region to react with char. This effect is more pronounced for fuel rich conditions. For example, Figure 2-3 shows at 15 percent OFA and a burner stoichiometric ratio of 0.97, the percent carbon in ash increases dramatically to 2.24. The carbon in ash can be reduced by increasing the available oxygen in the burner region. Table 2-3 and Figure 2-2(b) show that raising the burner stoichiometric ratio from 0.97 to 1.0 while maintaining 15 percent OFA lowers the carbon in ash from 2.25 to 1.3 percent.

Table 2-3 also shows that a minor reduction in the heat loss efficiency is expect to occur during OFA operation, primarily because of the loss in ash combustibles.

TABLE 2-3. UPRATED NOMINAL PERFORMANCE PREDICTIONS WITH OVERFIRE AIR (NO PLATEN UPGRADES)

	Uprated Nominal Baseline 950 MW	Uprated Nominal 5% OFA	Uprated Nominal 10% OFA	Uprated Nominal 15% OFA SRb = 0.97	Uprated Nominal 15% OFA SRb = 1.00 Cleaner PSH
Flue Gas O_2 (% wet)	2.50	2 50	2.50	2.50	2.95
Fuel Flow Rate (1000 lb/hr)	679	679	679	679	679
Flue gas Temperature (°F) Leaving					
FEGT	2,374	2,362	2,362	2,321	2,302
Backpass Inlet	1,384	1,388	1,389	1,387	1,381
Pri RH	759	754	760	754	743
Economizer	735	741	736	741	741
Mixing cup temperature (°F)					
Air Preheater In	746	747	747	747	742
Air Preheater Out	317	318	318	318	317
Flow Rates (1000 lb/hr)					
Main Steam	6,664	6,661	6,656	6,636	6,659
Reheat Steam	5,501	5,499	5,494	5,478	5,497
Attemperation flow (1000 lb/hr)					
Superheater	26	16	3	51	1
Reheater	0	0	0	0	0
Waterwall conductance (normalized) *	1.000	0.936	0.897	0.897	0.949
Flue gas split in Backpass (%)					
Pri RH	43.95	42.91	43.95	42.91	41.41
Pri SH / Econ	56.05	57.09	56.05	57.09	58.59
Water/Steam Temperatures (°F)					
Economizer In	549	549	549	549	549
Economizer Out	581	582	581	582	582
Waterwall Out	678	678	678	678	678
Pri SH Out	721	722	721	722	724
Platen SH Out	781	781	781	784	782
SH-Int Out	916	914	917	910	915
SH-Out Out	999	999	999	999	999
Cold RH In	630	630	630	630	630
Cold RH Out	816	815	818	815	813
Hot RH Out	1,005	1,004	1,005	1,005	1,006
Percent Carbon in ash	0.446	0.571	0.992	2.254	1.300
Heat Absorption (kW)					
Economizer	78,934	80,771	79,381	80,692	82,927
Waterwall	950,152	949,325	951,697	940,014	949,164
Primary SH	245,115	247,568	245,956	246,654	253,717
Platen SH	155,815	153,132	154,258	155,579	148,681
SH Int	242,479	237,084	237,965	242,204	234,218
SH Out	119,782	122,817	119,046	121,048	120,714
Pri RH	175,308	173,815	176,603	173,580	172,503
RH Out	166,082	167,107	164,608	167,134	169,577
Total Heat Absorption (kW)	2,133,667	2,131,619	2,129,514	2,126,905	2,131,501
ASME Heat Loss Efficiency (%)	88.98	88.95	88.90	88.74	88.73

* Conductance normalized with that at uprated nominal conditions (950 MW)

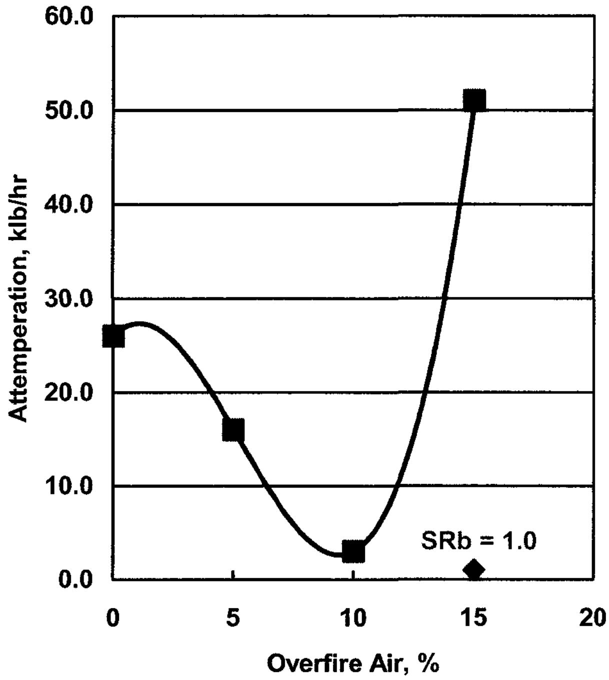

Figure 2-2(a). Superheater attemperation rate at different OFA operation conditions.

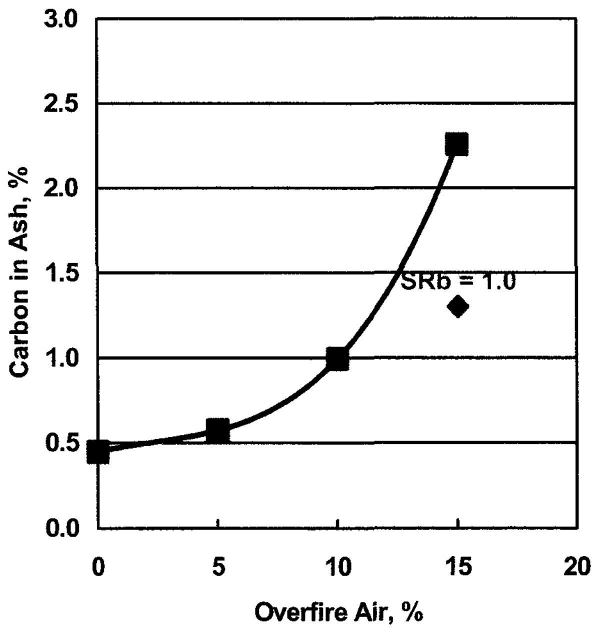

Figure 2-2(b). Percent carbon in ash at different OFA operation conditions.

2.2 Overfire Air Operation with Additional Platen Superheater Area

The boiler thermal model was the also used to show how platen exchanger upgrade impacts boiler performance. Test cases for baseline and 10 percent OFA with platen upgrades were simulated and compared with the earlier cases with no platen upgrades. The details of these simulations are given in Appendix 1.

Table 2-4 summarizes the comparison of baseline and 10 percent overfire air operating scenarios at uprated nominal full load conditions with and without the addition of platen superheater surface area. As expected, the additional platen surface area causes a significant increase in heat absorption in the platen superheater. This reduces the driving force in the remainder of the upper furnace convective region, lowering the heat duties in the intermediate and final superheaters and to a lesser degree in the final reheater. Minor changes in the fouling and split backpass flow ratio helps restore minor losses in reheat temperature. Once these adjustments were made, the net increase in overall superheater surface area results in a significantly higher superheat attemperation rate. Table 2-4 also shows that the platen upgrade has a minimal impact on carbon in ash and boiler thermal efficiency.

The mean gas temperature profiles for baseline 10 percent OFA at uprated nominal load with and without additional platen superheater area are shown in Figure 2-3. The figure shows that the platen superheater upgrade will have a minimal impact on the gas temperature distribution both for baseline and 10 percent OFA conditions.

In general, these results suggest that addition of platen superheater surface area with OFA helps maintain overall superheat absorption and an attemperation buffer. Any minor reduction in the reheat absorption profile can be recovered by adjusting the flue gas mass split in the backpass region, with minimal effects on boiler performance.

2.3 Increased Excess Air Operation with Additional Platen Superheater Area

A thermal performance study was carried out to evaluate the impacts of additional excess air on boiler performance when operated at uprated nominal conditions with additional platen

TABLE 2-4. UPRATED NOMINAL PERFORMANCE PREDICTIONS WITH 10 PERCENT OVERFIRE AIR (WITH PLATEN UPGRADES)

	Uprated Nominal Baseline 950 MW	Uprated Nominal 10% OFA	Uprated Nominal Baseline 950 MW Addl. Platen SH area	Uprated Nominal 10% OFA Addl. Platen SH area
Flue Gas O_2 (% wet)	2 50	2.50	2.50	2.50
Fuel Flow Rate (1000 lb/hr)	679	679	679	679
Flue gas Temperature (°F) Leaving				
FEGT	2,374	2,362	2,375	2,348
Backpass Inlet	1,384	1,389	1,377	1,387
Pri RH	759	760	765	758
Economizer	735	736	728	738
Mixing cup temperature (°F)				
Air Preheater In	746	747	745	747
Air Preheater Out	317	318	317	318
Flow Rates (1000 lb/hr)				
Main Steam	6,664	6,656	6,636	6,628
Reheat Steam	5,501	5,494	5,478	5,471
Attemperation flow (1000 lb/hr)				
Superheater	26	3	26	27
Reheater	0	0	0	0
Waterwall conductance (normalized) *	1.000	0.897	0.967	0.900
Flue gas split in Backpass (%)				
Pri RH	43.95	43.95	45.20	43.64
Pri SH / Econ	56.05	56.05	54.80	56.36
Water/Steam Temperatures (°F)				
Economizer In	549	549	549	549
Economizer Out	581	581	580	581
Waterwall Out	678	678	678	678
Pri SH Out	721	721	721	722
Platen SH Out	781	781	790	791
SH-Int Out	916	917	924	923
SH-Out Out	999	999	1,005	1,005
Cold RH In	630	630	630	630
Cold RH Out	816	818	819	817
Hot RH Out	1,005	1,005	1,005	1,005
Percent Carbon in ash	0.446	0.992	0.445	0.992
Heat Absorption (kW)				
Economizer	78,934	79,381	76,665	79,668
Waterwall	950,152	951,697	947,909	943,529
Primary SH	245,115	245,956	242,540	245,648
Platen SH	155,815	154,258	174,296	171,547
SH Int	242,479	237,965	234,501	232,710
SH Out	119,782	119,046	116,390	117,214
Pri RH	175,308	176,603	176,735	175,359
RH Out	166,082	164,608	163,794	161,979
Total Heat Absorption (kW)	2,133,667	2,129,514	2,132,830	2,127,654
ASME Heat Loss Efficiency (%)	88.98	88.90	88.99	88.89

* Conductance normalized with that at uprated nominal conditions (950 MW)

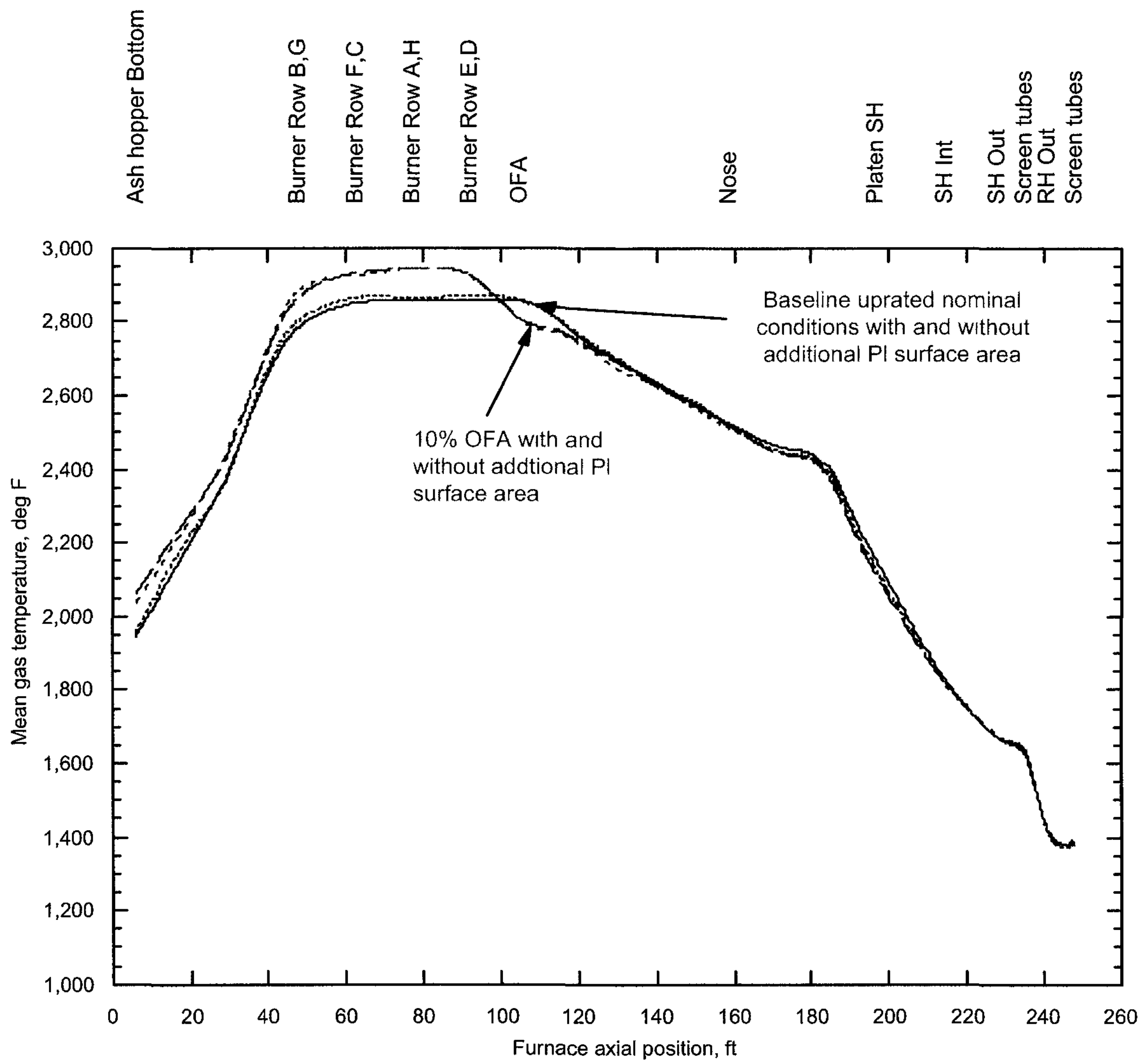

Figure 2-3. Predicted bulk furnace gas temperatures for uprated nominal baseline and overfire air conditions (with and without additional platen SH area).

superheater area. The excess air level was increased from the 2.50 percent to 3.0 percent $O_{2,wet}$ at the economizer outlet. This condition increased the overall stoichiometric ratio in the boiler to 1.18. A detailed explanation of the increased excess air analysis is presented in Appendix 1.

A summary of the results with increased excess air conditions is presented in Table 2-5. The increase of excess air in the burner zone tends to increase the sensible heating of the flue gas resulting in lower waterwall heat absorption and a lower steam generation rate. In this case, baseline steam flow conditions were re-established by reducing waterwall fouling (increasing the relative conductance). The additional air produces a higher flue gas mass flow rate that increases convective heat transfer to the exchangers in the upper furnace and backpass regions. Even with the increase in exchanger convective heat transfer, minor adjustments had to be made to the flue gas split in the backpass to restore superheat attemperation and reheat steam temperature. Carbon in ash at the boiler exit decreases as the excess air increases because more oxygen is available to react with char throughout the furnace flow path. The increase in excess air causes more dry gas heat loss reducing the heat loss efficiency by about 0.1 percent. A comparison of the gas temperature distribution between these two cases is shown in Figure 2-4. An increase in air supply to the burner zone causes a slight reduction in the overall gas temperatures.

2.4 Reduced Load Operation with Additional Platen Superheater Area

This section focuses on the impact that additional platen superheater area has on boiler performance at reduced load conditions. Boiler simulations were performed at 75 and 50 percent of the nominal uprated load corresponding to steam generation rates of 4.9 MMlb/hr and 3.3 MMlb/hr.

Design criteria provided by IPSC were used to set critical boiler operating parameters at different reduced load operating conditions. The original design specification recommended operating the burners in-service and out-of-service in a staggered arrangement. Five burners operate in service for 75 percent load and four burners operate in service at 50 percent load. The percent $O_{2,wet}$ settings at the economizer for 75 and 50 percent load conditions were set at 4.75 and 7.00 based

TABLE 2-5. UPRATED NOMINAL PERFORMANCE PREDICTIONS AT 3.0 PERCENT O_2 (WITH PLATEN UPGRADES)

	Uprated Nominal Baseline, 2.5% O_2 950 MW Additional Platen SH area	Uprated Nominal Baseline, 3.0% O_2 950 MW Additional Platen SH area
Flue Gas O_2 (% wet)	2.50	3.00
Fuel Flow Rate (1000 lb/hr)	679	679
Flue gas Temperature (°F) Leaving		
FEGT	2,375	2,382
Backpass Inlet	1,377	1,376
Pri RH	765	749
Economizer	728	738
Mixing cup temperature (°F)		
Air Preheater In	745	743
Air Preheater Out	317	318
Flow Rates (1000 lb/hr)		
Main Steam	6,636	6,625
Reheat Steam	5,478	5,469
Attemperation flow (1000 lb/hr)		
Superheater	26	96
Reheater	0	0
Waterwall conductance (normalized) *	0.967	1.000
Flue gas split in Backpass (%)		
Pri RH	45.20	42.57
Pri SH / Econ	54.80	57.43
Water/Steam Temperatures (°F)		
Economizer In	549	549
Economizer Out	580	583
Waterwall Out	678	678
Pri SH Out	721	723
Platen SH Out	790	797
SH-Int Out	924	922
SH-Out Out	1,005	1,005
Cold RH In	630	630
Cold RH Out	819	817
Hot RH Out	1,005	1,005
Percent Carbon in ash	0.445	0.286
Heat Absorption (kW)		
Economizer	76,665	82,492
Waterwall	947,909	929,639
Primary SH	242,540	247,206
Platen SH	174,296	178,131
SH Int	234,501	237,836
SH Out	116,390	118,465
Pri RH	176,735	174,717
RH Out	163,794	165,276
Total Heat Absorption (kW)	2,132,830	2,133,762
ASME Heat Loss Efficiency (%)	88.99	88.85

* Conductance normalized with that at uprated nominal conditions (950 MW)

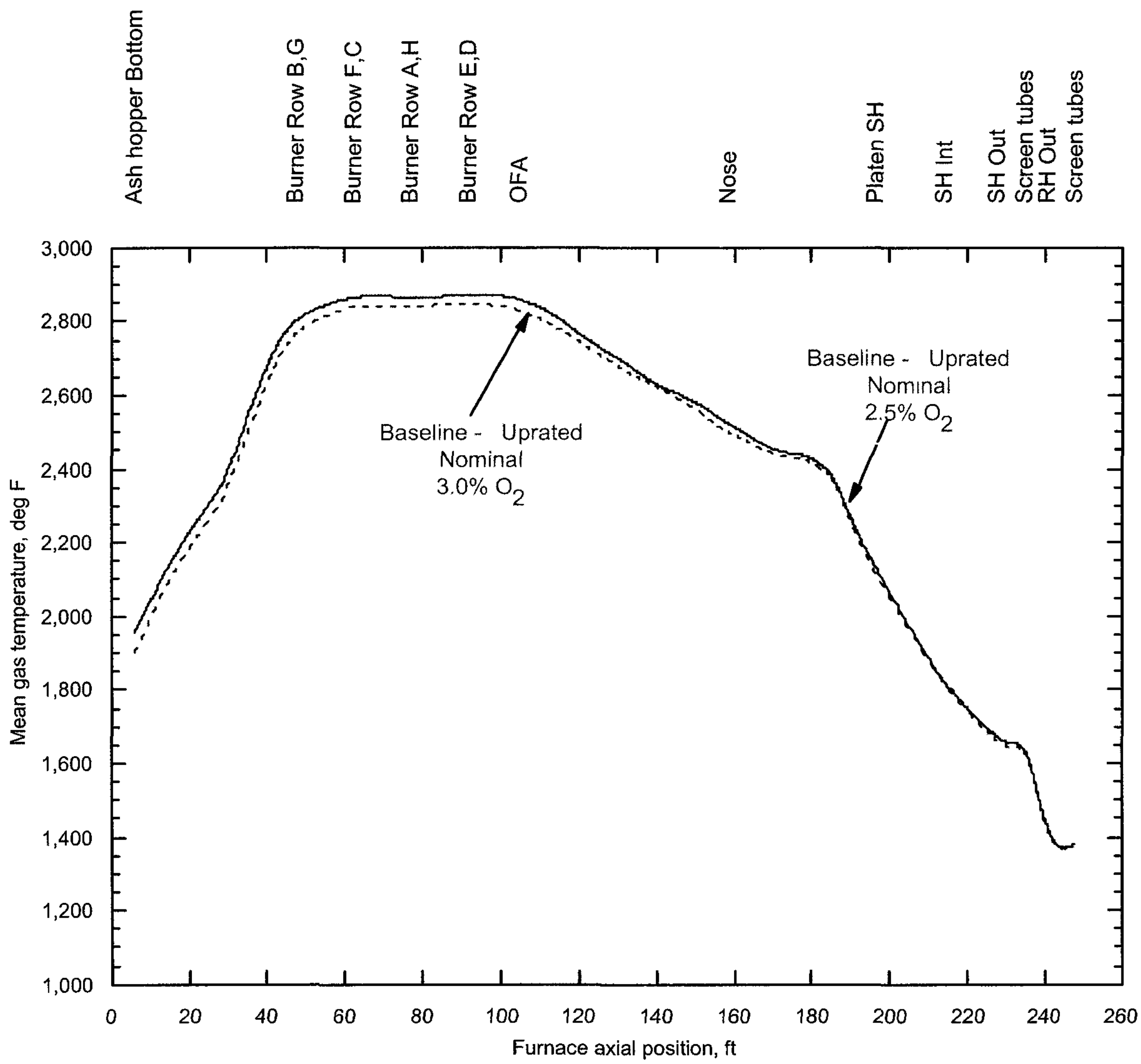

Figure 2-4. Predicted bulk furnace gas temperatures for uprated nominal conditions with 3.0 % O_2 (with additional Platen surface area).

on a design curve. The detailed results 75 and 50 percent load conditions with additional platen superheat area are described in Appendix 1.

Table 2-6 summarizes the results obtained for the reduced load conditions. As boiler load is reduced, the fuel flow is reduced to account for the reduction in heat input. To retain burner flame characteristics and maintain steam temperature, burners rows are taken out of service and excess air levels are increased. Early model simulations showed that operating the boiler with the recommended staggered burners-in-service arrangement produced excessive steam generation rates that could not be reduced without making unreasonably large changes to waterwall and exchanger fouling. Therefore, to reduce waterwall heat absorption, the burners in service were moved to the upper rows, reducing the amount of waterwall exposed to hot gas and lowering gas residence time. Minor changes were also made to waterwall and convective region fouling characteristics and the flue gas mass split ratio to finally restore main and reheat steam flows, temperatures, and the primary steam attemperation rate. Table 2-6 also shows that the ASME heat loss efficiency decreases with reduction in load, primarily due to dry gas heat loss.

The gas temperature distribution shown in Figure 2-5 shows that furnace temperatures drop severely as the load is reduced. As the load is reduced the low temperature cut-off in the burner region moves higher in the furnace, e.g. from burner rows B,G to burner rows A,H, because burners are being taken out of service in the lower region of the furnace.

2.5 Baseline Operation with Other Fuels and Additional Platen Superheater Area

All of the thermal performance analyses discussed in the previous sections have been calibrated and simulated firing of Fuel A. This section discusses the impacts that different fuels, also fired in the IGS steam generators, have on boiler performance. The case studies have been run at uprated nominal load conditions with the platen superheater upgrade. The fuel analyses for the different fuels A, B, C, D and E are summarized in Table 2-2. For each case study, each fuel flow rate was adjusted to a value that produces the same total dry heat input as that for uprated nominal conditions with fuel A. The excess air content was maintained at the same level as the

TABLE 2-6. PERFORMANCE PREDICTIONS AT REDUCED LOAD CONDITIONS (WITH PLATEN UPGRADES)

	Uprated Nominal Baseline 950 MW Additional Platen SH area	75% Nominal load Mills BGF OOS Additional Platen SH area	50% Nominal load Mills BGFC OOS Additional Platen SH area
Flue Gas O_2 (% wet)	2.50	4.75	7.00
Fuel Flow Rate (1000 lb/hr)	679	509	354
Flue gas Temperature (°F) Leaving			
FEGT	2,375	2,221	2,045
Backpass Inlet	1,377	1,326	1,257
Pri RH	765	743	740
Economizer	728	761	787
Mixing cup temperature (°F)			
Air Preheater In	745	754	771
Air Preheater Out	317	304	291
Flow Rates (1000 lb/hr)			
Main Steam	6,636	4,970	3,482
Reheat Steam	5,478	4,103	2,874
Attemperation flow (1000 lb/hr)			
Superheater	26	55	9
Reheater	0	0	0
Waterwall conductance (normalized) *	0.967	0.967	0.885
Flue gas split in Backpass (%)			
Pri RH	45.20	39.40	33.90
Pri SH / Econ	54.80	60.60	66.10
Water/Steam Temperatures (°F)			
Economizer In	549	549	549
Economizer Out	580	585	587
Waterwall Out	678	678	678
Pri SH Out	721	723	723
Platen SH Out	790	797	796
SH-Int Out	924	924	930
SH-Out Out	1,005	1,005	1,005
Cold RH In	630	630	630
Cold RH Out	819	814	796
Hot RH Out	1,005	1,005	976
Percent Carbon in ash	0.445	0.050	0.006
Heat Absorption (kW)			
Economizer	76,665	66,014	49,739
Waterwall	947,909	695,905	488,579
Primary SH	242,540	186,492	131,300
Platen SH	174,296	132,483	93,144
SH Int	234,501	177,310	120,626
SH Out	116,390	86,382	56,733
Pri RH	176,735	123,751	75,221
RH Out	163,794	123,447	79,577
Total Heat Absorption (kW)	2,132,830	1,591,784	1,094,919
ASME Heat Loss Efficiency (%)	88.99	88.68	88.19

* Conductance normalized with that at uprated nominal conditions (950 MW)

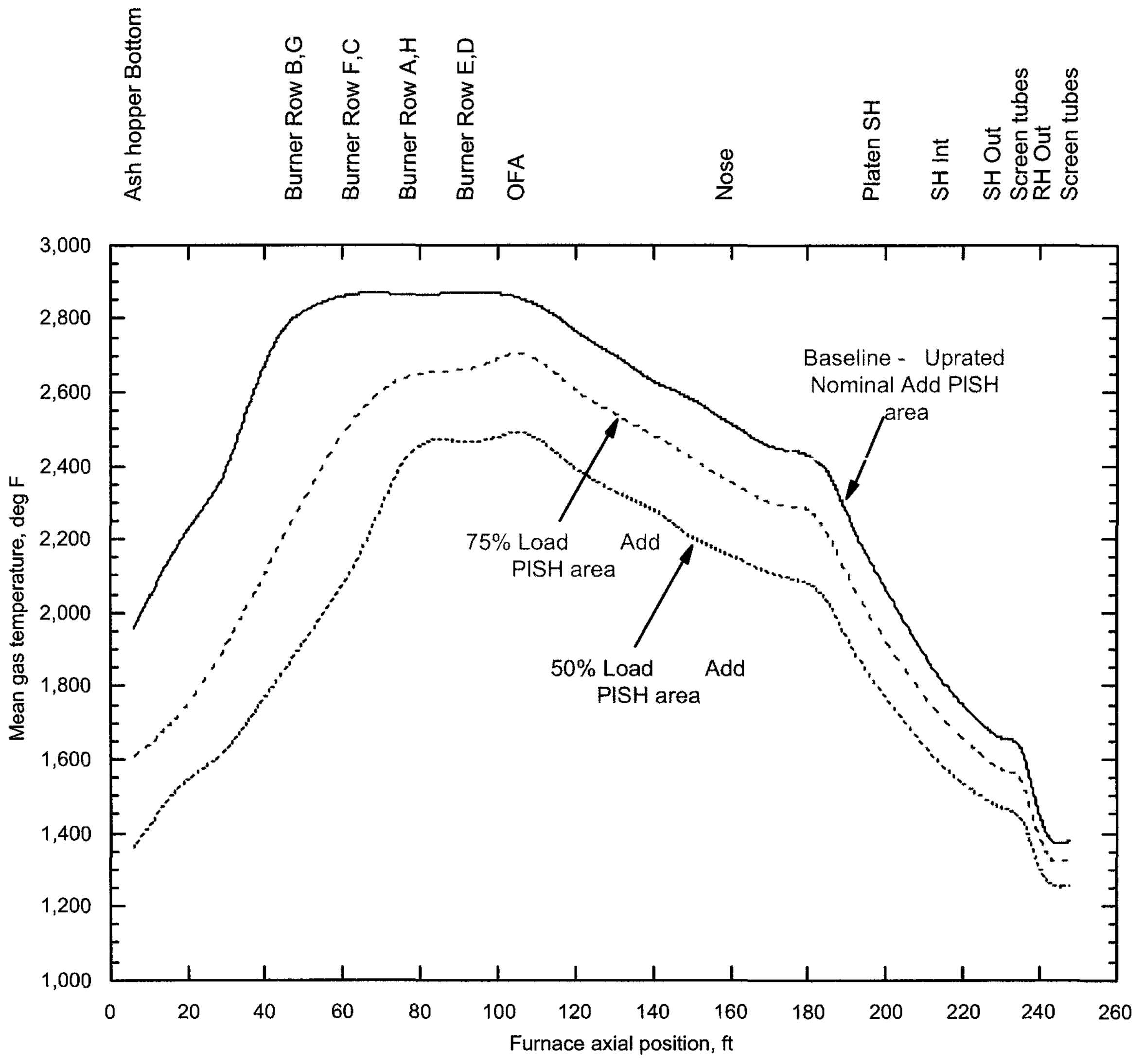

Figure 2-5. Predicted bulk furnace gas temperatures for reduced load conditions (with additional platen SH area).

previous simulations with fuel A (2.5 percent $O_{2,wet}$). As before, the stepwise details of the fuels case study is provided in Appendix 1.

Table 2-7 summarizes the fuels case study results at nominal operating conditions. If necessary, adjustments to waterwall fouling and split backpass flow ratio have been make to restore nominal operating conditions with Fuel A. The results shows that Fuels B and D, which have heating values less than Fuel A, require cleaner waterwalls. The reduction in wall fouling is necessary because both of these fuels have larger fuel rates than Fuel A and therefore produce more flue gas. More flue gas increases gas sensible heating and lowers gas source temperatures, thus requiring cleaner walls to maintain waterwall heat absorption. The relatively lower furnace gas temperatures for Fuels B and D can be seen in Figure 2-6.

In contrast to these results, Fuels C and E, which have heating values greater than Fuel A, require additional wall fouling. Figure 2-6 shows that the gas temperature distributions for these two fuels are very close to that for Fuel A.

In all cases, superheat attemperation and reheat steam temperature could be re-established by making these adjustments to waterwall fouling and minor adjustment to the split backpass flow ratio. Table 2-7 also shows that Fuel D, the lowest heating value fuel, reduces the boiler thermal efficiency by about 1.3 percent. All of the fuels yield more carbon in ash than Fuel A. Fuel E, which has the largest ratio of fixed carbon to ash, produces a baseline carbon in ash of 0.83, which is about twice as large as that for Fuel A. Because IPSC interested in the projected maximum carbon in ash during OFA operation, a test case was run with Fuel E at 10 percent OFA.

The results for 10 percent overfire air operation with fuel E is summarized in Table 2-8. Overfire air operation increases waterwall absorption, lowers the FEGT, and reduces the main steam attemperation rate. Carbon in ash increases from 0.83 to 1.81. Figure 2-7 also shows that a 10 percent OFA conditions cause a small reduction in boiler thermal efficiency relative to baseline operation. The mean gas temperature distributions, similar to those discussed earlier, are shown

TABLE 2-7. UPRATED NOMINAL BASELINE PERFORMANCE PREDICTIONS WITH DIFFERENT FUELS (WITH PLATEN UPGRADES)

	Uprated Nominal Baseline 950 MW Fuel A	Uprated Nominal Baseline 950 MW Fuel B	Uprated Nominal Baseline 950 MW Fuel C	Uprated Nominal Baseline 950 MW Fuel D	Uprated Nominal Baseline 950 MW Fuel E
Flue Gas O_2 (% wet)	2.50	2.50	2.50	2.50	2.50
Fuel Flow Rate (1000 lb/hr)	679	692	644	720	629
Flue gas Temperature (°F) Leaving					
FEGT	2,375	2,345	2,397	2,345	2,389
Backpass Inlet	1,377	1,380	1,388	1,360	1,386
Pri RH	765	732	729	744	731
Economizer	728	754	743	735	740
Mixing cup temperature (°F)					
Air Preheater In	745	745	737	738	736
Air Preheater Out	317	320	313	319	312
Flow Rates (1000 lb/hr)					
Main Steam	6,636	6,609	6,635	6,589	6,655
Reheat Steam	5,478	5,456	5,477	5,439	5,493
Attemperation flow (1000 lb/hr)					
Superheater	26	84	103	85	99
Reheater	0	0	0	0	0
Waterwall conductance (normalized) *	0.967	1.025	0.967	1.072	0 967
Flue gas split in Backpass (%)					
Pri RH	45.20	39.47	40.12	39.91	40.61
Pri SH / Econ	54.80	60.53	59.88	60.09	59.39
Water/Steam Temperatures (°F)					
Economizer In	549	549	549	549	549
Economizer Out	580	585	584	585	583
Waterwall Out	678	678	678	678	678
Pri SH Out	721	725	725	726	724
Platen SH Out	790	797	798	796	798
SH-Int Out	924	922	922	924	923
SH-Out Out	1,005	1,005	1,005	1,005	1,005
Cold RH In	630	630	630	630	630
Cold RH Out	819	811	811	809	810
Hot RH Out	1,005	1,005	1,005	1,005	1,005
Percent Carbon in ash	0.445	0.488	0.643	0.579	0.826
Heat Absorption (kW)					
Economizer	76,665	88,211	85,632	88,855	84,030
Waterwall	947,909	923,267	926,878	919,330	932,143
Primary SH	242,540	252,901	252,910	253,469	251,440
Platen SH	174,296	171,022	174,229	167,186	176,750
SH Int	234,501	235,535	238,581	239,308	239,867
SH Out	116,390	117,786	118,544	115,225	117,757
Pri RH	176,735	169,062	169,754	167,025	169,325
RH Out	163,794	169,851	170,541	170,828	171,825
Total Heat Absorption (kW)	2,132,830	2,127,635	2,137,069	2,121,226	2,143,137
ASME Heat Loss Efficiency (%)	88.99	88.27	88.75	87.69	89.07

* Conductance normalized with that at uprated nominal conditions (950 MW)

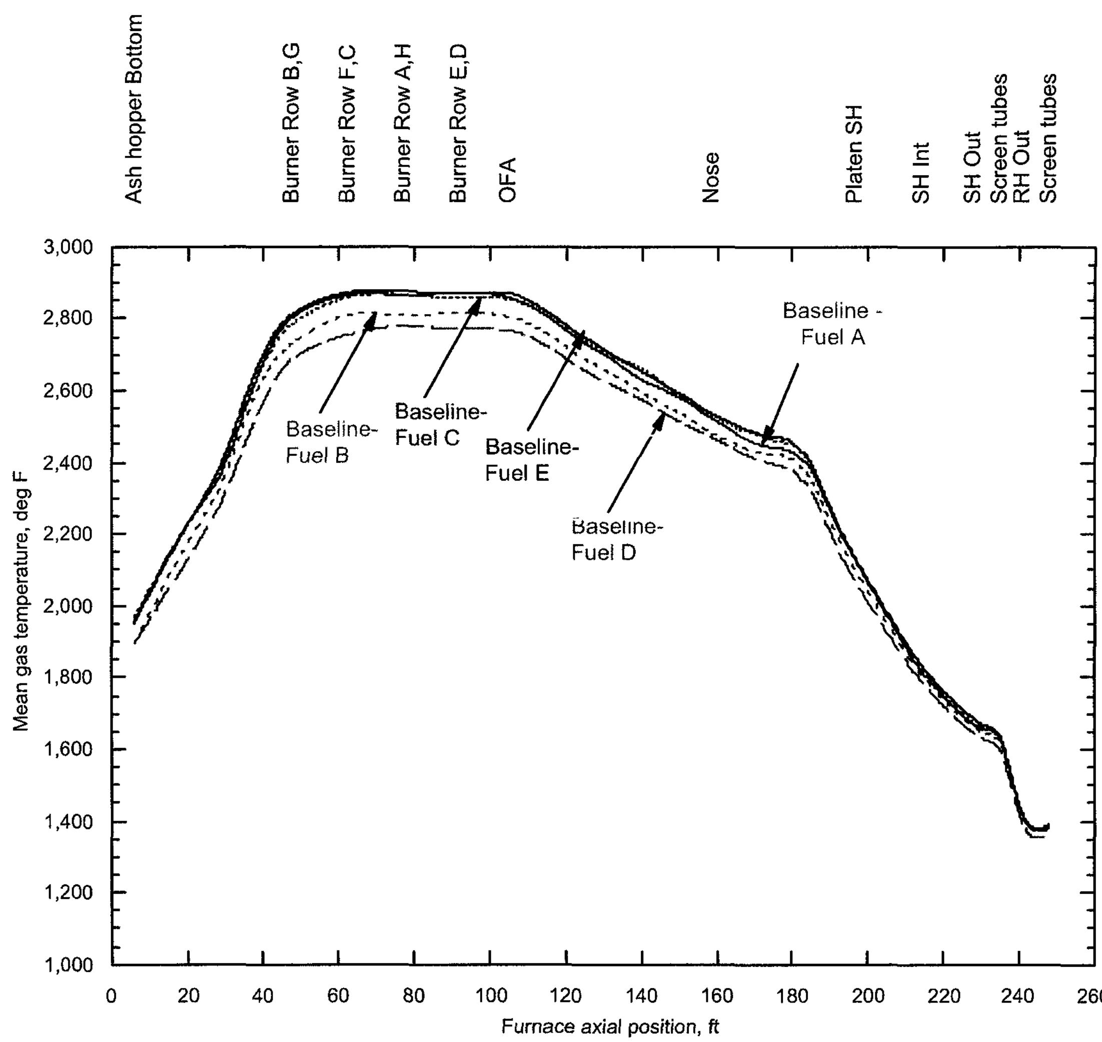

Figure 2-6. Predicted bulk furnace gas temperatures for uprated nominal conditions and different fuels (with additional platen SH area).

TABLE 2-8. UPRATED NOMINAL BASELINE PERFORMANCE PREDICTIONS WITH 10 PERCENT OFA AND FUEL E (WITH PLATEN UPGRADE)

	Uprated Nominal Baseline 950 MW Fuel E Additional Platen SH area	Uprated Nominal 10% OFA Fuel E Additional Platen SH area
Flue Gas O_2 (% wet)	2.50	2.50
Fuel Flow Rate (1000 lb/hr)	629	629
Flue gas Temperature (°F) Leaving		
FEGT	2,389	2,342
Backpass Inlet	1,386	1,380
Pri RH	731	747
Economizer	740	725
Mixing cup temperature (°F)		
Air Preheater In	736	734
Air Preheater Out	312	311
Flow Rates (1000 lb/hr)		
Main Steam	6,655	6,659
Reheat Steam	5,493	5,497
Attemperation flow (1000 lb/hr)		
Superheater	99	52
Reheater	0	0
Waterwall conductance (normalized) *	0.967	0.967
Flue gas split in Backpass (%)		
Pri RH	40.61	43.59
Pri SH / Econ	59.39	56.41
Water/Steam Temperatures (°F)		
Economizer In	549	549
Economizer Out	583	581
Waterwall Out	678	678
Pri SH Out	724	722
Platen SH Out	798	791
SH-Int Out	923	921
SH-Out Out	1,005	1,005
Cold RH In	630	630
Cold RH Out	810	817
Hot RH Out	1,005	1,005
Percent Carbon in ash	0.826	1.806
Heat Absorption (kW)		
Economizer	84,030	79,281
Waterwall	932,143	944,963
Primary SH	251,440	247,422
Platen SH	176,750	170,659
SH Int	239,867	237,419
SH Out	117,757	120,487
Pri RH	169,325	175,904
RH Out	171,825	165,600
Total Heat Absorption (kW)	2,143,137	2,141,735
ASME Heat Loss Efficiency (%)	89.07	89.00

* Conductance normalized with that at uprated nominal conditions (950 MW)

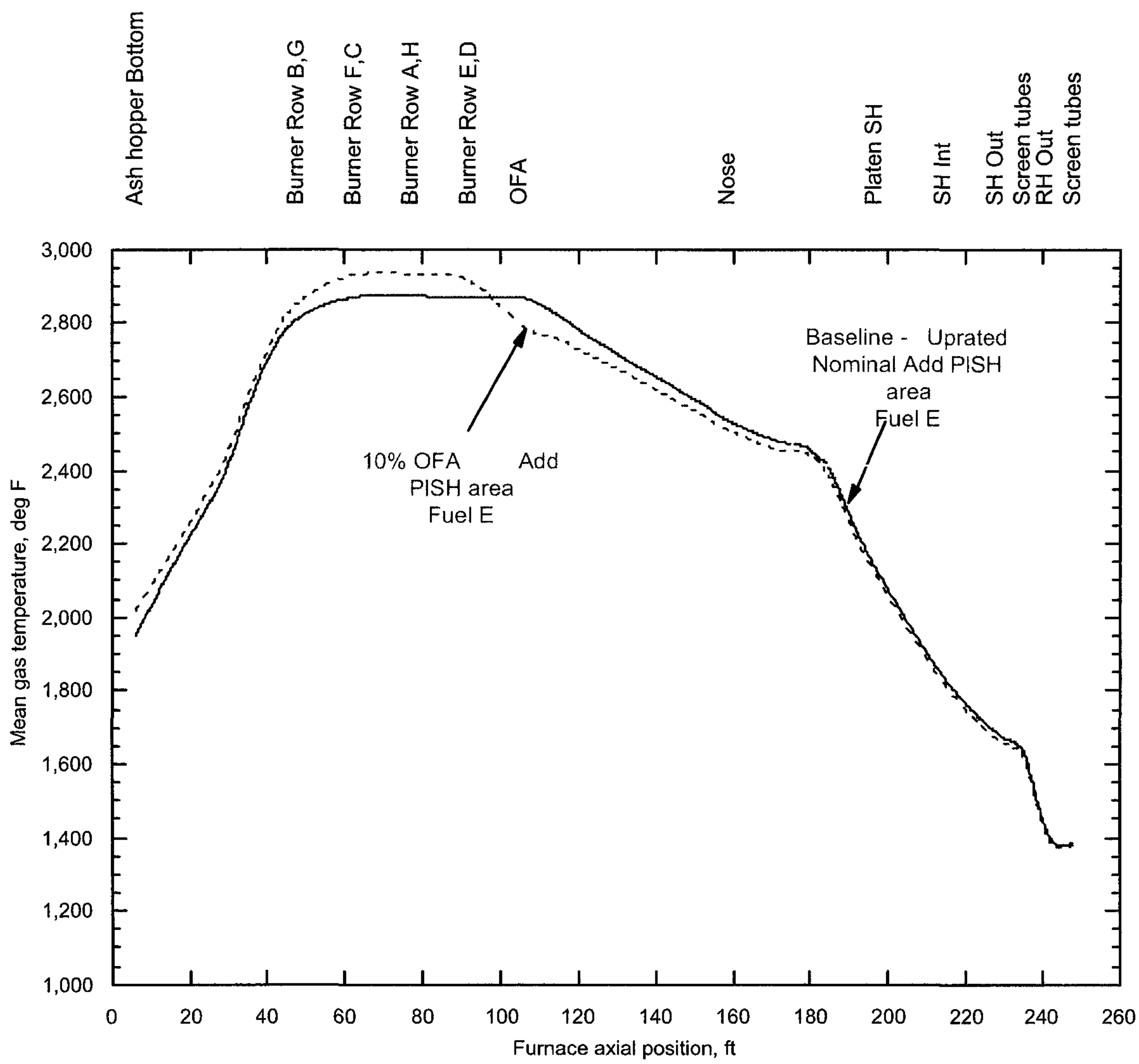

Figure 2-7. Predicted bulk furnace gas temperatures for uprated nominal conditions with 10% OFA and Fuel E (with additional Platen SH area).

in Figure 2-7. A lower stoichiometric ratio in the burner region leads to higher gas temperatures in the burner region, which eventually recover near the entrance to the backpass.

2.6 Conclusions

A boiler thermal model for IGS Unit 2 has been developed to examine the impacts that overfire air, excess air, and the addition of platen surface area have on boiler performance for uprated nominal conditions and reduced load conditions. The effect of different fuels on uprated nominal load performance with additional platen superheater area has also been evaluated. The model was calibrated with field data at both uprated MCR and original nominal load conditions (875 MW).

The results show that relative to the uprated nominal load conditions, operating with OFA is expected to increase carbon in ash and reduce main steam attemperation. Increased furnace fouling is necessary to maintain steam temperatures and attemperation rates. The overall impacts of OFA operation on boiler performance are minimal.

The platen modification increases main steam attemperation rates, even with OFA operation. Overall boiler performance could be also maintained with the platen upgrade. Boiler performance can be maintained for the range of fuels burned, provided that furnace heat absorption can be controlled to accommodate furnace characteristics. Boiler performance can also be maintained with increased excess air, but attemperation rates are project to increase. Running with the lower burner rows out of service is recommended for reduced load operating conditions. Fuel E shows a significant increase in carbon in ash during OFA operating conditions, suggesting that values may exceed 2 percent when running at OFA levels above 10 percent total air. The case studies with additional excess air, reduced loads, and different fuels suggest that boiler efficiency does not change significantly.

3.0 Computational Fluid Dynamics (CFD) Study

A furnace CFD model of the IGS furnace has been developed, using FLUENT 6.0 software, to investigate the impact that overfire air (OFA) and platen superheater upgrades will have on local gas temperatures and compositions in the IGS steam generators. The primary goal of the study is to determine how effectively the OFA mixes with the flue gas and investigate its ability to oxidize carbon monoxide for uprated nominal flow conditions (950 MW). Understanding how the flow field and CO distribution change between baseline and OFA operating conditions provides insights into overall system behavior and can lead to changes in operating scenarios and conditions that improve overall system performance. A CFD model of one IGS burner has also been developed to predict burner metal temperatures during uprated nominal OFA operating conditions.

Prior to running the CFD models with the proposed upgrades, the model grids were constructed, calibrated using field data, and corroborated with baseline predictions from the boiler thermal model. Appendix 2 describes the computational domains, CFD grids, physical models, setup, and calibration procedure for both furnace and burner CFD models. Table 3-1 gives a summary of the key operating parameters for the baseline and overfire air conditions investigated using the furnace CFD model. Parametric settings for the burner metal temperature CFD case studies are provided in Table 3-2.

Section 3.1 gives a comparison of the furnace CFD results for baseline and OFA operation prior to platen heat exchanger modifications. Section 3.2 describes furnace model CFD predictions with platen exchanger surface modifications and Section 3.3 presents burner CFD model results comparing how uprated nominal baseline and OFA operation affect burner local metal temperatures.

3.1 Overfire Air Operation (Uprated Nominal Load)

The CFD furnace model was used to investigate the impact that OFA operation without the platen upgrade has on local gas temperatures, local composition, and CO oxidation. Table 3-3

TABLE 3-1. FURNACE CFD MODEL CASE STUDIES

Case Type	Load	OFA Injector Characteristics	Fuel Type	OFA % Total Air	% $O_{2,wet}$
OFA without Platen SH Upgrate	Uprated Nominal (950 MW)	Fully Open, 2/3 open	Fuel A	0, 10	2.5
OFA with Platen SH Upgrade	Uprated Nominal	Fully Open	Fuel A	0, 10	2.5

TABLE 3-2. BURNER CFD MODEL CASE STUDIES

Case Type	Load	OFA % Total Air	Burner Total Air Flow Rate klb/hr	Burner Primary Air Flow Rate klb/hr	Burner Sec. Air Flow Rate klb/hr	Gas Source Temperature °F	Inner/Outer Secondary Air Flow Ratio	%$O_{2,wet}$
Burner in Service	Baseline (875 MW)	0	166.1	29.9	136.2	2733	1/4	3.3
Burner in Service	Uprated Nominal (950 MW)	0	165.2	29.7	135.5	2784	1/4	2.5
Burner in Service	Uprated Nominal (950 MW)	10	151.7	29.7	122.0	2884	1/4	2.5
Burner Out of Service	Uprated Nominal (950 MW)	0	19.0	0.0	19.0	2784	1/4	2.5
Burner Out of Service	Uprated Nominal (950 MW)	10	19.0	0.0	19.0	2884	1/4	2.5

TABLE 3-3. FURNACE CFD MODEL PARAMETERS AND AVERAGE RESULTS

Input		Baseline	10% SOFA
Primary Air	lb/hr	1,249,539	1,249,539
Secondary Air	lb/hr	5,692,320	4,998,120
SOFA	lb/hr	0	694,200
Coal Flow	lb/hr	679,000	679,000
Output			
Exit O_2 (wet)	%	2.56	2.57
Exit CO (wet)	ppm	102	199

gives a comparison of the flow conditions, and average oxygen and CO concentrations at the backpass entrance for baseline and 10 percent OFA conditions (10 percent of the total air mass flow rate). When the exit oxygen concentration is held constant, the CO concentration at the backpass entrance increases from 102 ppm for baseline conditions to 199 ppm at 10 percent OFA conditions. Figure 3-1 illustrates the mean gas temperatures between the hopper and nose plane. The mean gas temperature profiles for both operating conditions are similar to those generated by the boiler thermal model. Relative to baseline conditions, 10 percent OFA produces higher gas temperatures in the burner region and lower gas temperatures above the OFA injectors. The detailed temperature, composition, and velocity fields shown in Figures 3-2 – 3-12 help explain the increase in average CO concentration at 10 percent OFA.

Figure 3-2 provides a comparison of side-view gas temperature contours for baseline and 10 percent OFA conditions. The side-slice passes through a central burner. Relative to baseline conditions, the 10 percent OFA case has higher temperatures in the burner region and slightly lower temperatures near the OFA injectors. The temperature contours in the upper furnace for both conditions appear to be similar suggesting the fluid mixes out relative well in the upper furnace.

Figure 3-3 gives a comparison of side-view oxygen concentration contours for baseline and 10 percent OFA conditions. This figure provides an indication of how the OFA mixes with the flue gas. For OFA conditions, the figure clearly shows that oxygen is depleted in the center of the furnace just above the OFA injectors, primarily because the OFA jets do not penetrate very deeply into the furnace. The oxygen also appears to be distributed relative uniformly in the upper furnace indicating that relative good mixing occurs in the upper furnace.

As mentioned earlier, the OFA system has been design with a partitioned damper system to control the OFA jet velocity and mass flow rate. One recommended damper operating scenario is to close off one-third of the OFA cross-section to increase the flow velocity at the OFA outlet. This condition was simulated in the furnace CFD model by reducing the OFA cross-section by one-third while maintaining mass flow rate at 10 percent OFA. Figure 3-4 shows that even with the increased injector outlet velocity, the jet still does not penetrated the central region of the

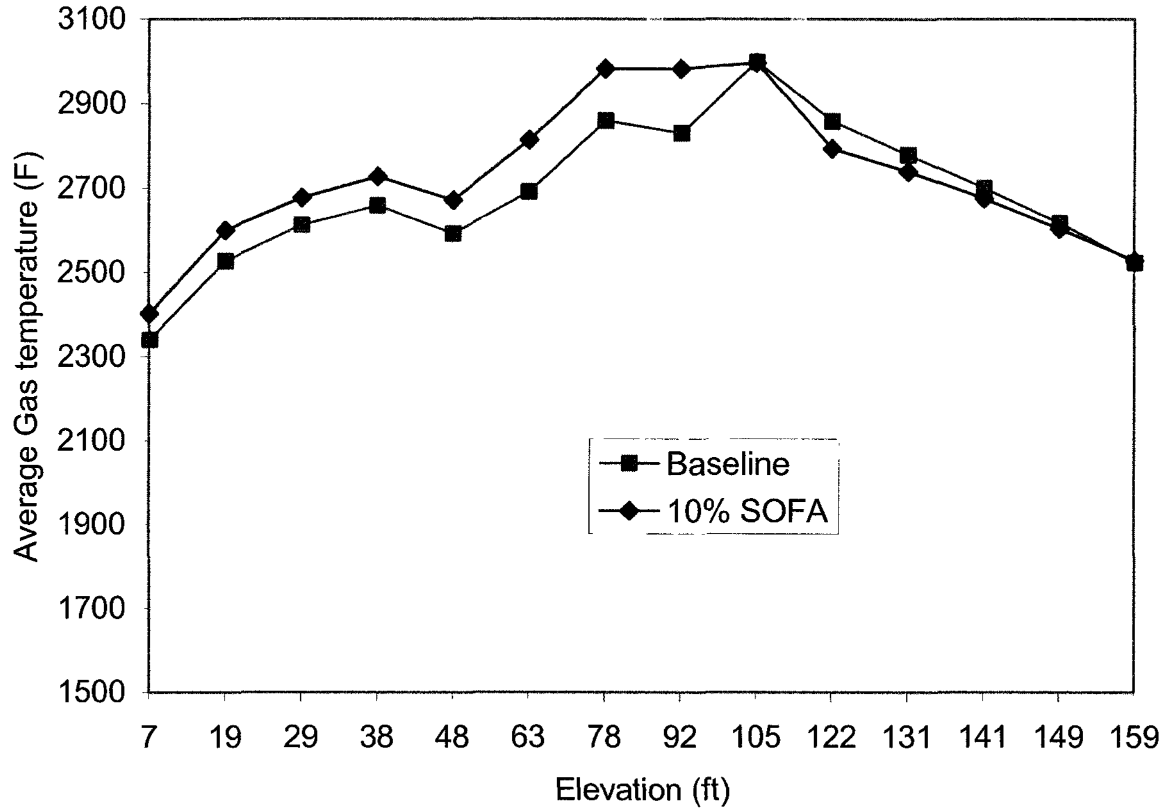

Figure 3-1. Average gas temperatures below the furnace nose.

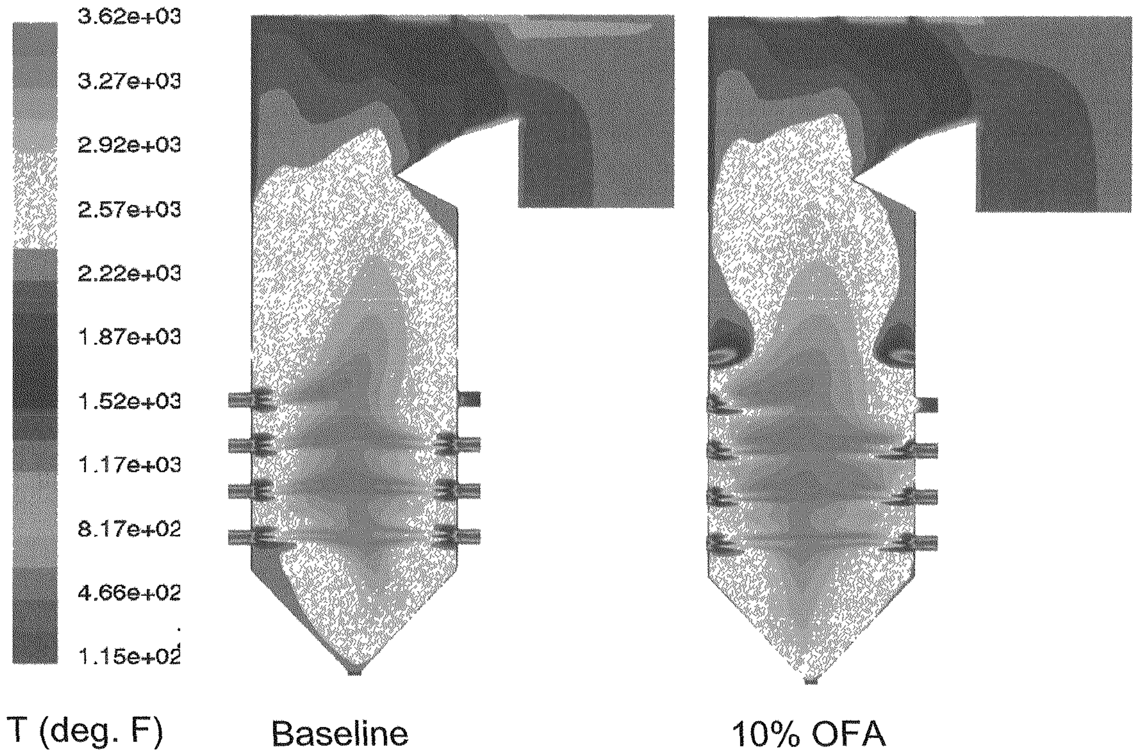

Figure 3-2. Comparison of side-view temperature contours.

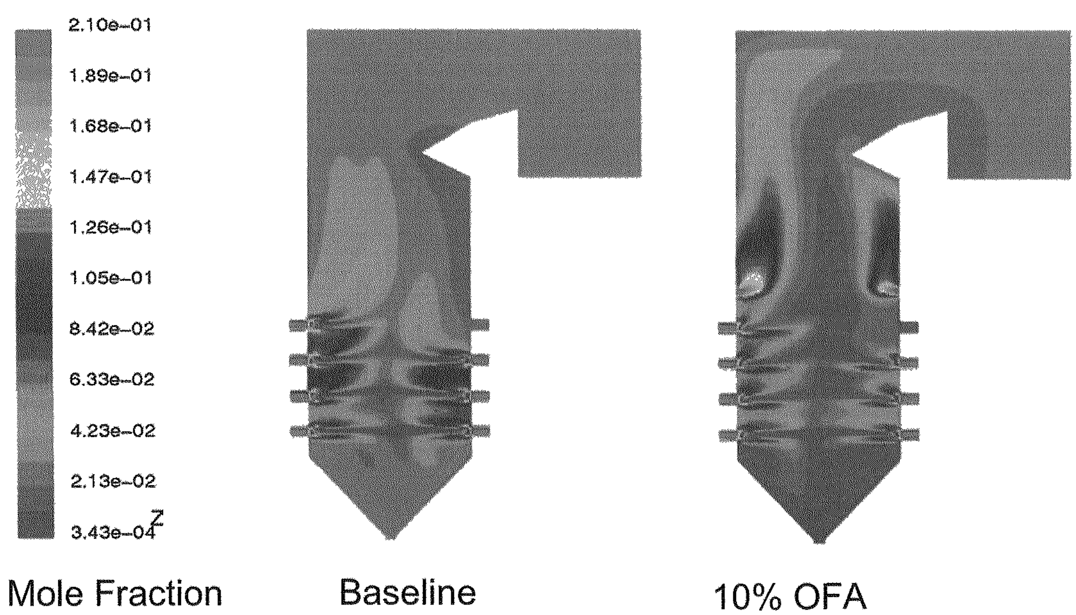

Figure 3-3. Comparison of side-view O_2 mole fraction contours.

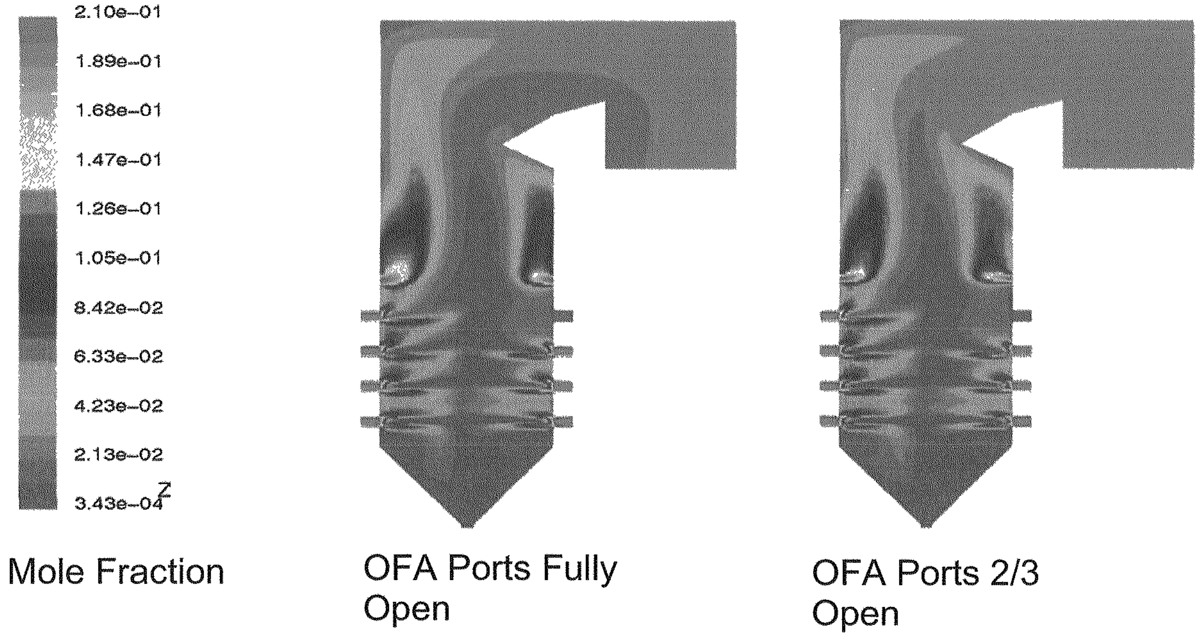

Figure 3-4. Comparison of side-view O_2 mole fraction contours with different OFA injector cross-sectional areas (10 percent OFA).

furnace very well. The air mixes out slightly better in the upper furnace resulting in a slight improvement in CO oxidation (discussed later).

The weak jet penetration has been corroborated with an in-house GE jet-in-crossflow computer program whose results are illustrated for different OFA flow conditions in Figure 3-5. At 10 percent OFA, the jet coverage appears to be about 60 percent of the duct width, with the remaining uncovered 40 percent in the central region of the furnace. Increasing the OFA flow rate (jet mass rate and velocity) appear to improve the jet penetration and mixing rate. However, extrapolating these curves deep into the center region of the furnace is not recommended because the relatively simple jet-in-crossflow program assumes a uniform velocity profile, which does not exist in opposed wall-fired boilers, as shown by Figure 3-6.

Figure 3-6 provides furnace cross-sectional contours of the gas velocity magnitude at the OFA injector and nose planes. Flue gas from the burners is channeled up through the central region of the furnace creating a high-velocity shear layer. High-velocity shear layers also exist on the side walls and in the corners of the front wall creating a skewed I-beam velocity contour. The I-beam velocity contour is commonly found in opposed wall-fired furnaces. In this case, the skewness in the contour toward the front wall occurs because the upper rear wall burner row was out of service (OOS) for this case study. Changing the OOS burner row location will likely change the degree of skewness in the I-beam velocity contour; e.g., moving the OOS burner row to lower furnace elevations will likely reduce the skewness.

Figure 3-6 also suggests that high upward shear rates in the center region of the furnace prevent the overfire air jets from penetrating deeply into the flow field. The high gas velocities on the side and front wall corners also prevent the air from penetrating into these regions, causing low air coverage near the side walls. In contrast to the front wall flow phenomena, air coverage is relatively uniform between the side walls in the rear-wall region because the upper rear-wall burner is out of service. The non-uniformity in OFA coverage may be improved by biasing the flow in the OFA injectors.

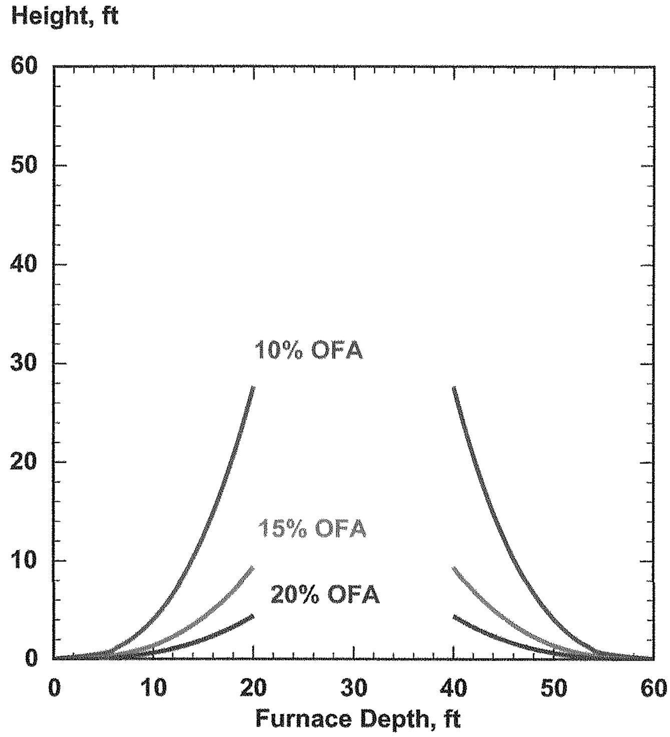

Figure 3-5. Estimation of jet penetration into the furnace for different OFA mass injection rates.

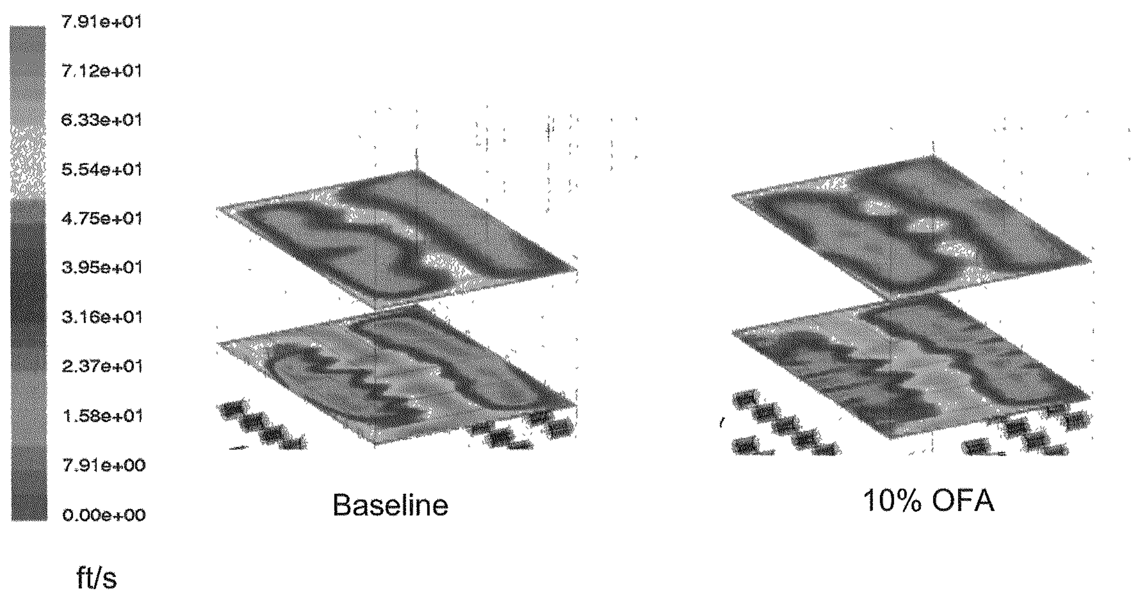

Figure 3-6. Comparison of velocity magnitude contours at the OFA injection and furnace nose planes.

The three-dimensional characteristics of gas fluid lumps from the second burner row are clearly delineated by the path lines shown in Figure 3-7. A path line, colored by temperature, tracks a lump of fluid through its entire flow path. The figure shows that the flow from the second burner row concentrates at the furnace center in the burner region. As the flow move upward it expands outward toward the wall, eventually filling the entire furnace cross-section. The relatively smooth path lines indicate that non-uniform concentration contours that may exist in the lower furnace will probably map well into the back pass region, where a CEMS grid measuring CO or O_2 can be used for burner fuel and/or air balancing.

Path lines from the OFA injectors are depicted in Figure 3-8. Although these path lines are relatively smooth, the lines in the front-row central burner region dip downward because the gas flow from the front-wall burner row entrains some of the overfire air. The figure also shows that very little air entrainment occurs near the rear wall because the upper rear-wall burner row is out of service.

Relative to baseline conditions, Figure 3-9 clearly shows that the lack of overfire air penetration and mixing reduces CO oxidation in the center of the furnace just below the nose plane. The high CO concentration in the center of the furnace is also slightly biased toward the rear wall of the furnace. Figure 3-10 gives a comparison of side-view CO concentration contours above the OFA injection elevation. As the gas moves from the OFA injection plane to the backpass entrance, significantly less CO is oxidized for OFA conditions. The figure also shows that CO levels are larger in the center of the furnace at the backpass entrance. This is more clearly delineated by the CO concentration contours at the vertical backpass entrance plane shown in Figure 3-11. For OFA conditions, the concentration characteristics of the gas map very well from the OFA injection plane to the backpass entrance plane: the high CO concentration between the backpass entrance side walls has retained its identity. The high CO concentration has shifted closer to the lower furnace wall in the convective pass. Although CO will continue to oxidize as the gas flows through the boiler backpass (up to temperatures ~ 1600 °F), the CO concentration contour should retain its identity into the air heater inlet duct. Measuring the CO concentration with a CEMS

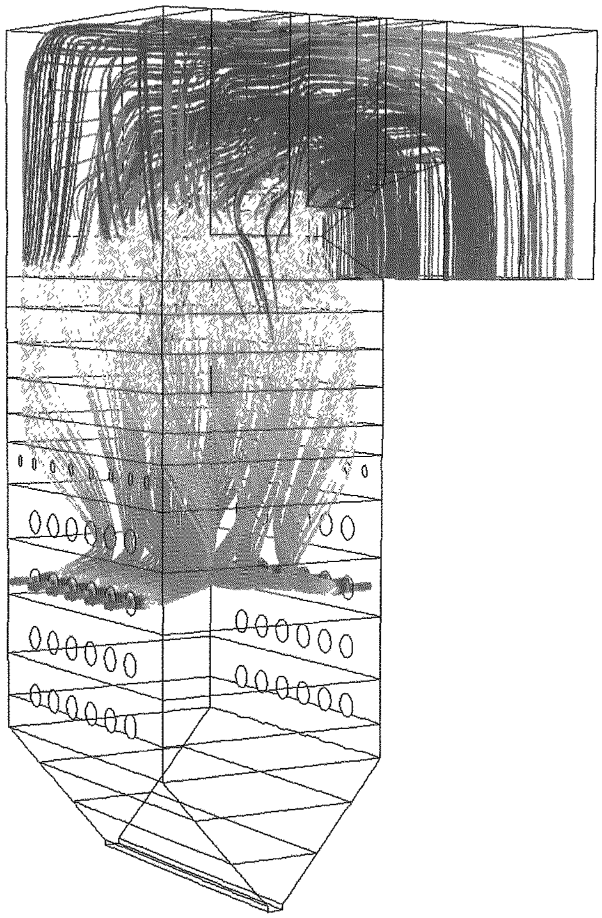

Figure 3-7. Burner path lines for baseline conditions.

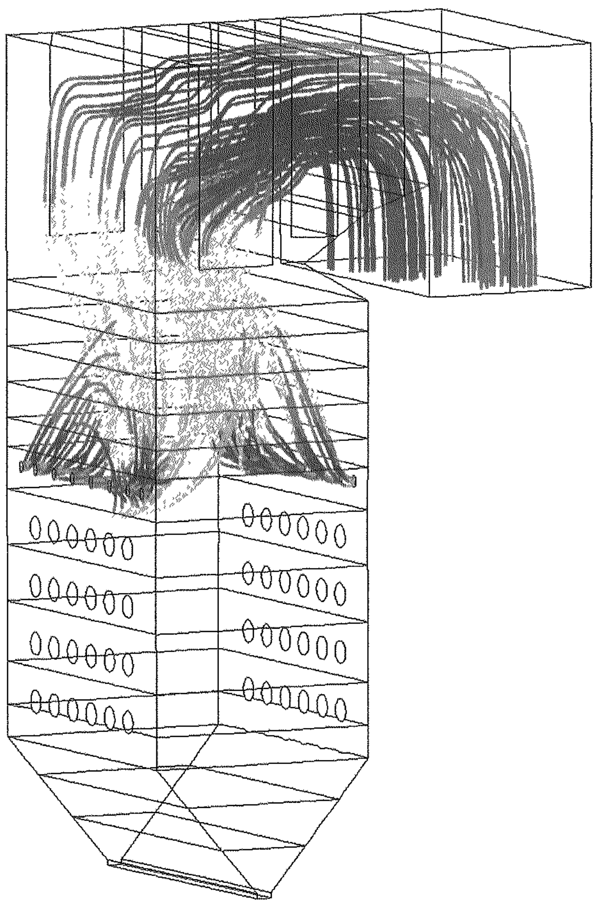

Figure 3-8. Air path lines at 10 percent OFA.

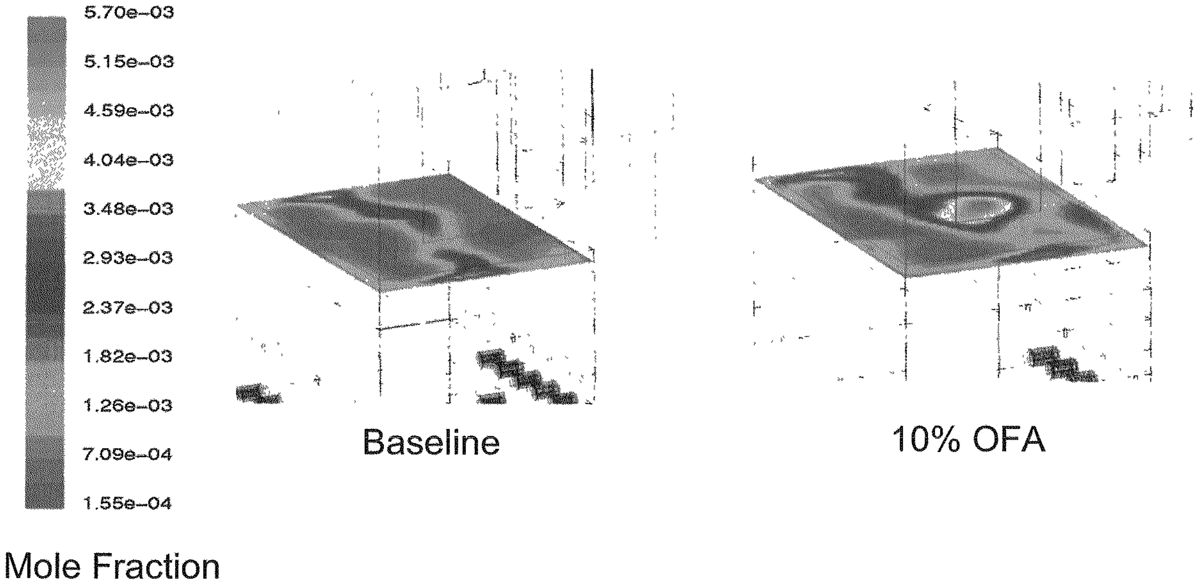

Figure 3-9. Comparison of CO mole fraction contours at the furnace nose plane.

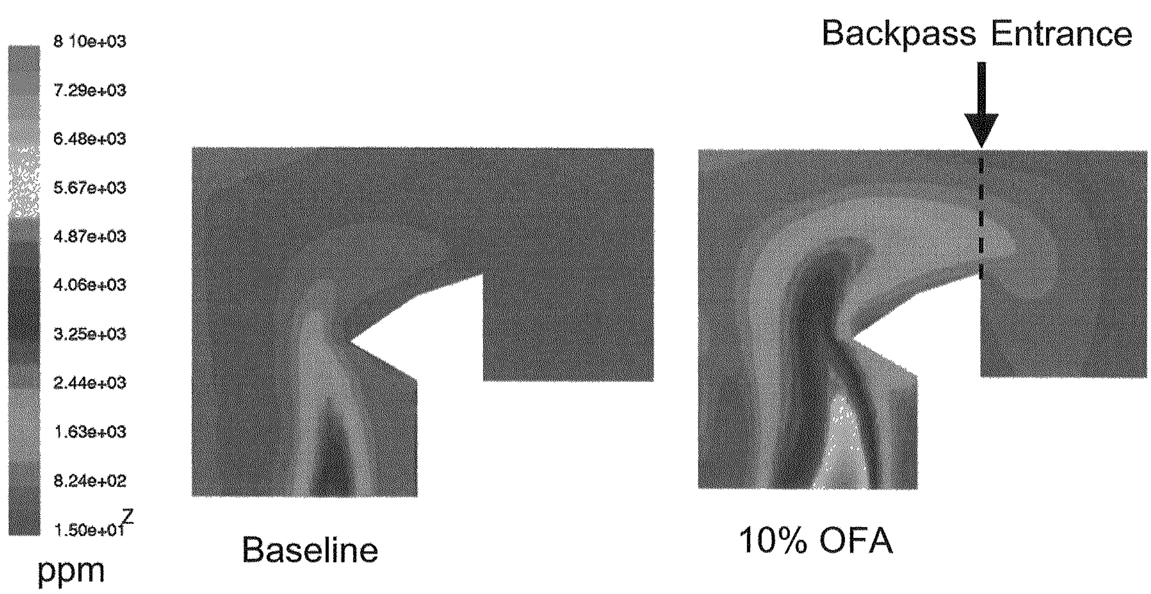

Figure 3-10. Comparison of side-view CO concentration (ppm) above the OFA injection plane

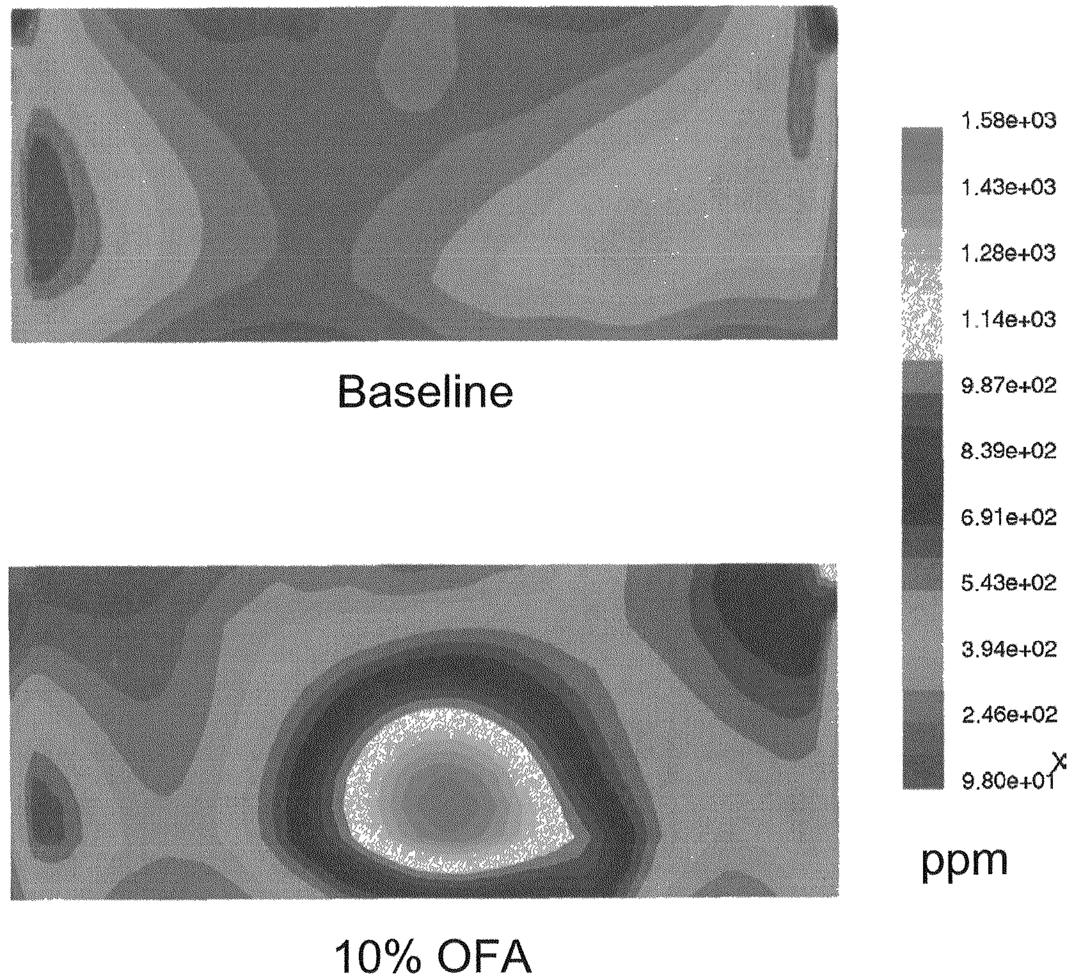

Figure 3-11. Comparison of CO concentration contours (ppm) at backpass entrance plane.

grid in the air heater inlet duct should be useful in devising OFA flow biasing schemes that improve CO oxidation and reduce average CO emissions.

Figure 3-12 gives the CO concentration contours at the vertical backpass entrance plane for different OFA injection cross-sectional areas. As discussed earlier, reducing the OFA injector outlet cross-sectional area by one-third results in a minor decrease in the CO concentration at the backpass entrance. The mass-weighted average reduction in CO is from 199 ppm for a fully open injector outlet to 191 ppm for a two-thirds open injector outlet.

3.2 Overfire Air Operation with Additional Platen Surface Area

The CFD furnace model was also used to investigate the impact that OFA operation with the platen upgrade has on local gas temperatures, local composition, and CO oxidation. Table 3-4 gives a comparison of the flow conditions, and average oxygen and CO concentrations at the backpass entrance for conditions with and without the platen exchanger modification. Adding platen surface area results in no change in the average CO concentration at baseline conditions (102 ppm) and a small change from 199 to 194 ppm for 10 percent OFA conditions. Figure 3-13 also shows that the mean gas temperatures between the hopper and nose plane remain the nearly identical after the platen exchanger modification. In fact, all the contour plots discussed in Section 3.1 showed similar behavior with the addition of platen surface area. For example, the similar behavior with the platen upgrade is shown in Figures 3-14 and 3-15, which illustrate side-view gas temperature and O_2 mole-fraction contours. Because of the similar nature in the detailed contour plots and CFD results with those in Section 3.1, no further discussion of the furnace CFD modeling results with the platen exchanger modification was deemed necessary.

3.3 Burner Thermal Impact Study

The burner CFD model was developed and used to investigate the impact that OFA operation will have on burner metal temperatures. The calibration procedure, given in Appendix 2, was based on field temperature data taken at the original nominal load (875 MW). The flow split ratio between inner and outer secondary airflow rates was fixed at ¼. In this section, a comparison of the baseline

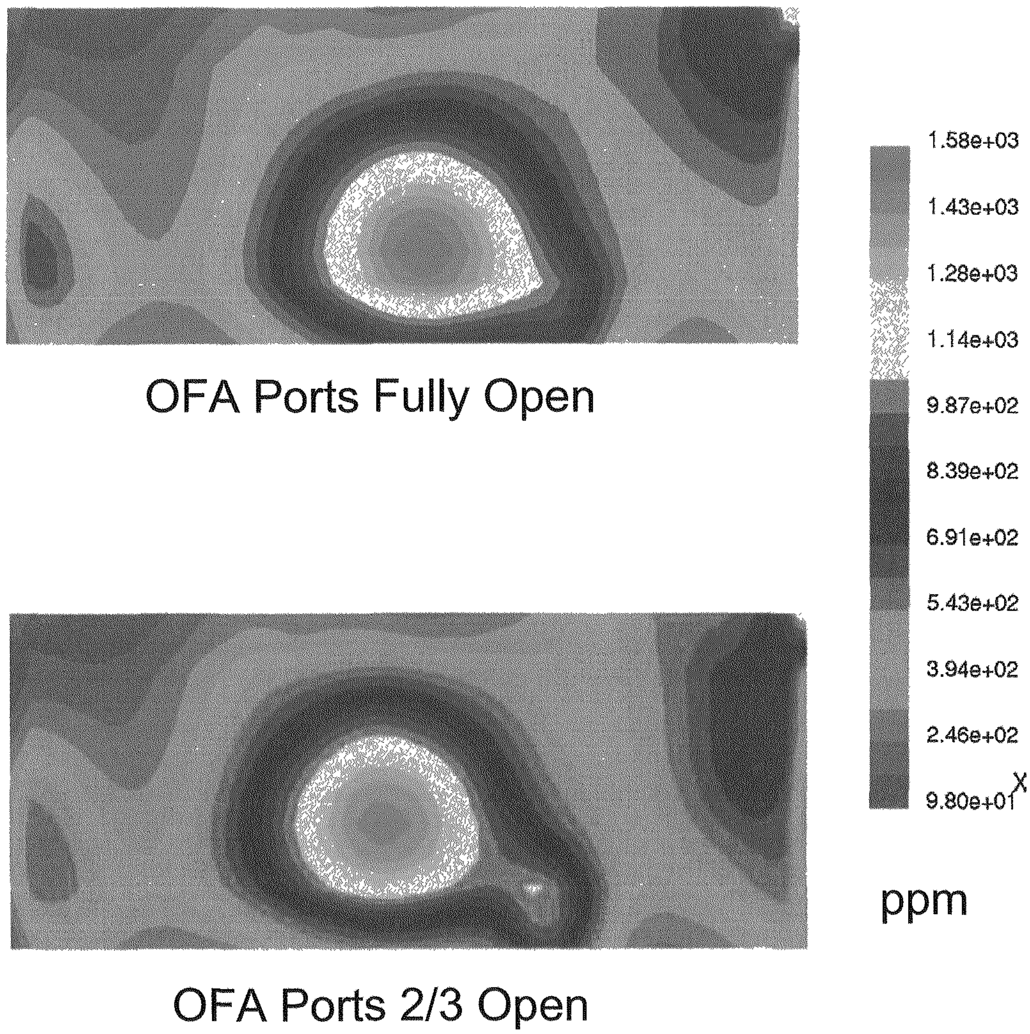

Figure 3-12. CO concentration contours (ppm) at backpass entrance plane for different OFA injector cross-sectional areas.

TABLE 3-4. FURNACE CFD MODEL PARAMETERS AND AVERAGE RESULTS WITH ADDITIONAL PLATEN SURFACE AREA

Input		Baseline	10% SOFA	Baseline w/Platen Mods	10% SOFA w/ Platen Mods
Primary Air	lb/hr	1,249,539	1,249,539	1,249,539	1,249,539
Secondary Air	lb/hr	5,692,320	4,998,120	5,692,320	4,998,120
SOFA	lb/hr	0	694,200	0	694,200
Coal Flow	lb/hr	679,000	679,000	679,000	679,001
Output					
Exit O2 (wet)	%	2.56	2.57	2.56	2.57
Exit CO (wet)	ppm	102	199	102	194

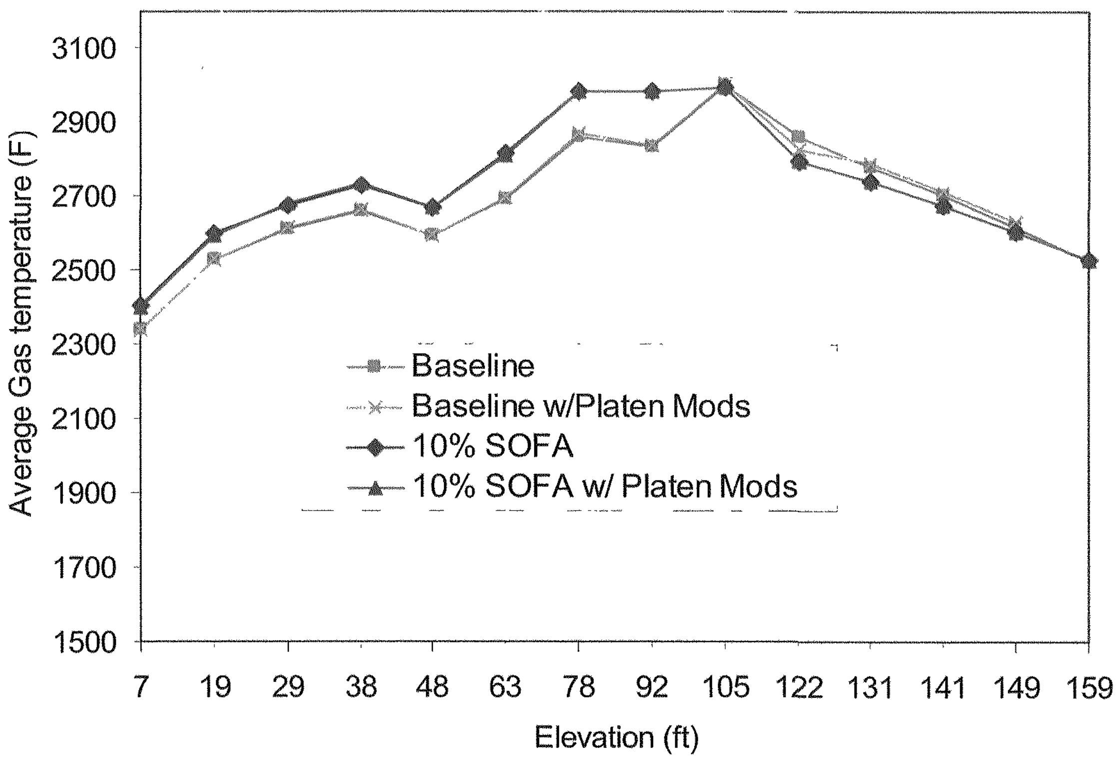

Figure 3-13. Average gas temperatures below the furnace nose with and without additional platen surface area.

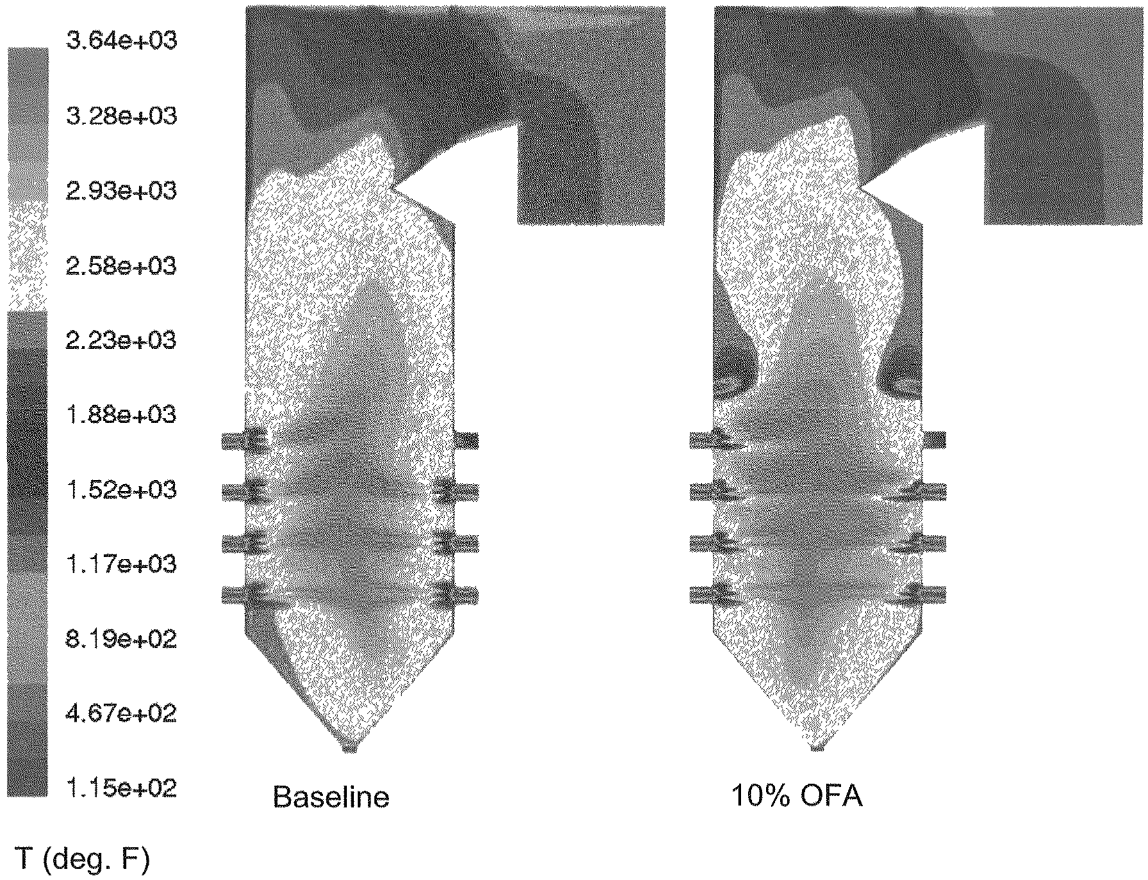

Figure 3-14. Comparison of side-view temperature contours with additional platen surface area.

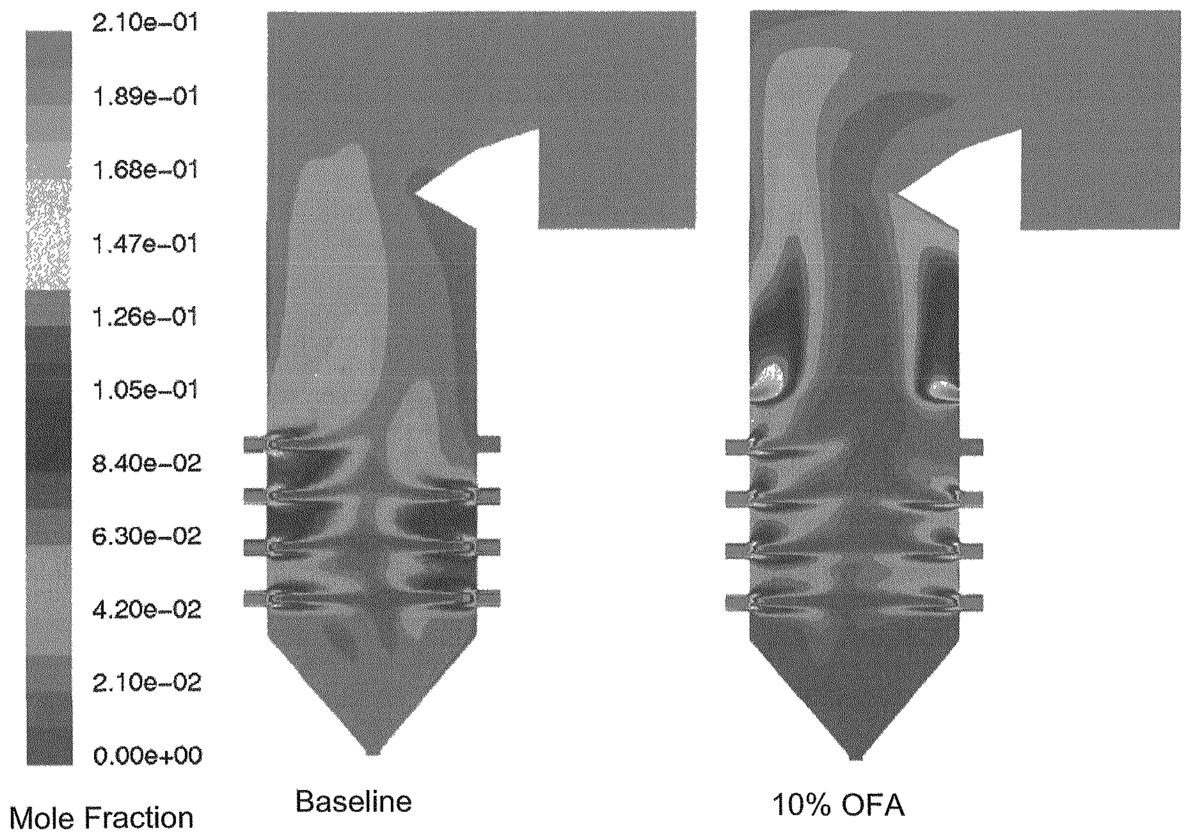

Figure 3-15. Comparison of side-view O_2 mole fraction contours with additional platen surface area.

temperature distribution on the rear wall of the burner outer secondary airflow duct is made between baseline and uprate nominal conditions both with the burner in and out of service.

Figures 3-16 – 3-19 show the gas velocity and burner wall temperature profiles for baseline flow conditions (875 MW), which look nearly the same as those for rest of the case studies. Because 80 percent of the secondary air flows through the outer secondary airflow duct, the velocity exiting the duct approaches 145 ft/s. The velocities through the inner secondary and primary flow channels are moderate between 20 – 60 ft/s. The wall temperature contours, given in Figures 3-17 and 3-18, show that a moderate temperature gradient occurs on the rear back plate of the outer secondary flow duct, primarily in the region near the inner secondary air pipe that is exposed to the gas source temperature. The temperature at the wall thermocouple location is 942 ^{o}F, which is very close to 945 ^{o}F from the field data. The temperatures on the rear plate wall range from about 969 to 790 ^{o}F. Also, the temperature at the tip of the outer tube holding the flame stabilizer is very high, approaching over 2000 ^{o}F.

Figure 3-19 compares the baseline temperature profiles on the rear plate of the outer secondary air duct at original baseline conditions (875 MW) with those at uprated nominal load conditions (950 MW) with a burner in service. At nominal uprated load conditions with no overfire air, the figure shows that the wall temperature profile is nearly the same as that for original baseline conditions. At the thermocouple location, the temperature increases from 942 to 953 ^{o}F. When 10 percent of the total air is shifted to the OFA injectors, the wall temperatures increases from about 10 to 30 ^{o}F, depending on location. The temperature at the thermocouple location increases from 953 to 979 ^{o}F, whereas the maximum temperature near the base of the rear wall plate of the outer secondary airflow channel, changes from about 980 to 1010 ^{o}F. The increase in temperature for OFA conditions is caused by an increase in the source gas temperature and a decrease in the outer secondary airflow rate (see numbers in Table 3-2). The impact of these effects is clarified in Figure 3-20.

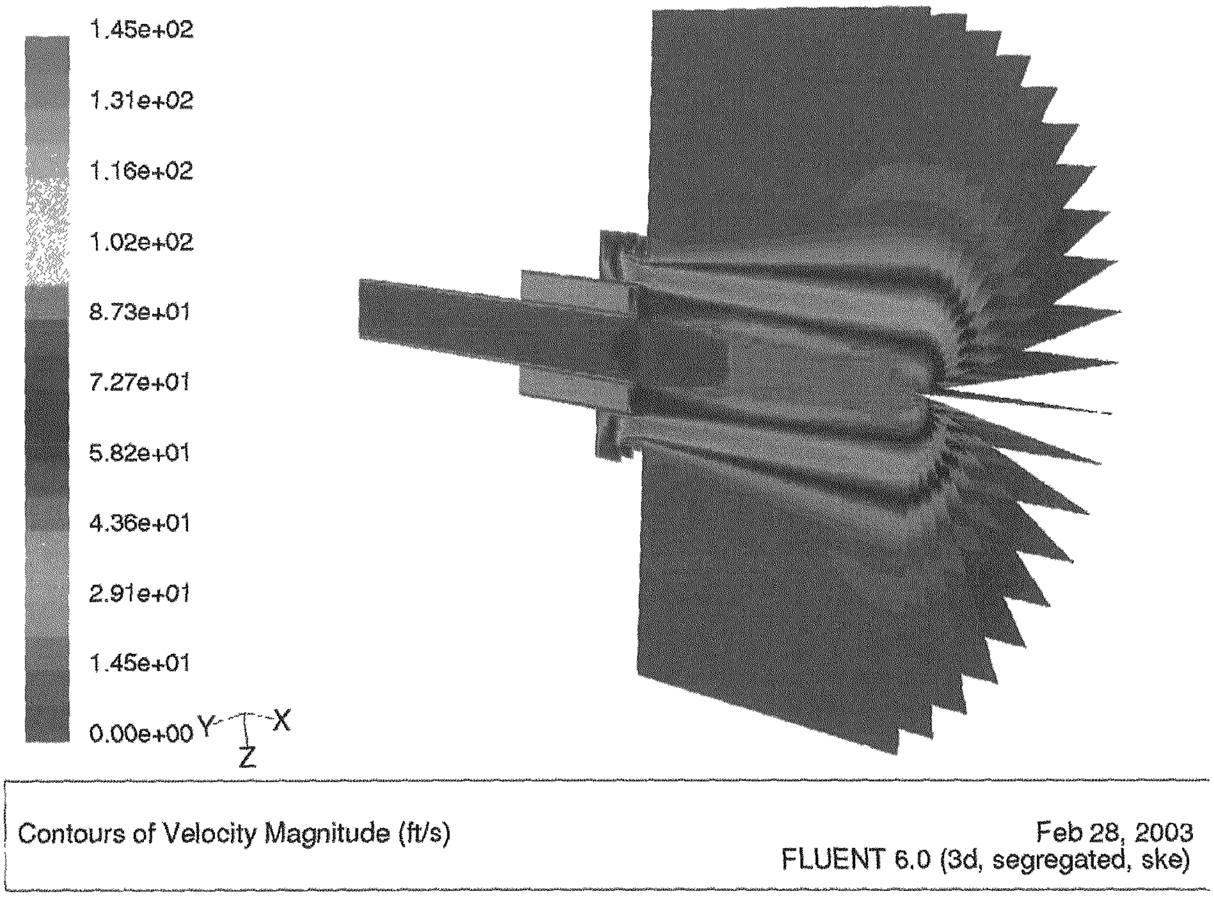

Figure 3-16. Burner in service air/fuel velocity contour at 875 MW.

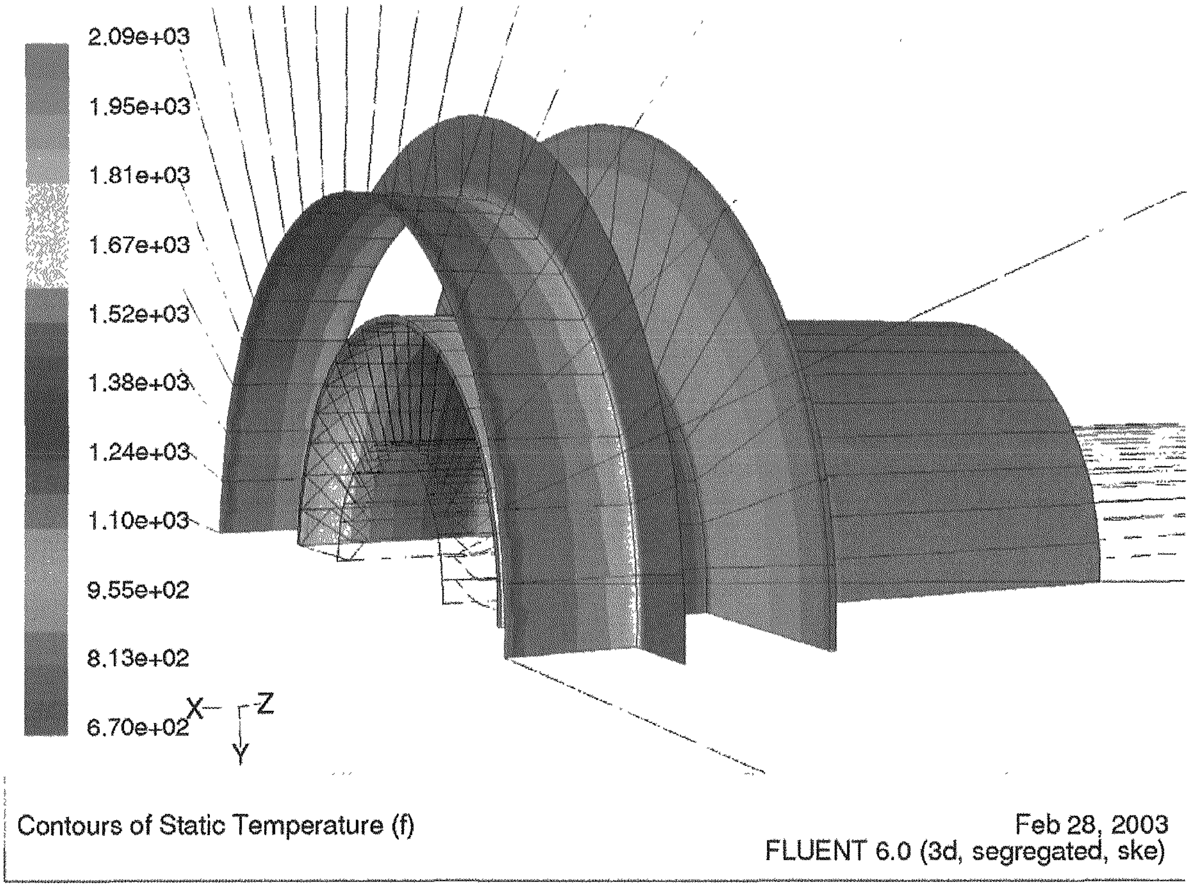

Figure 3-17. Burner in service wall temperature contours at 875 MW.

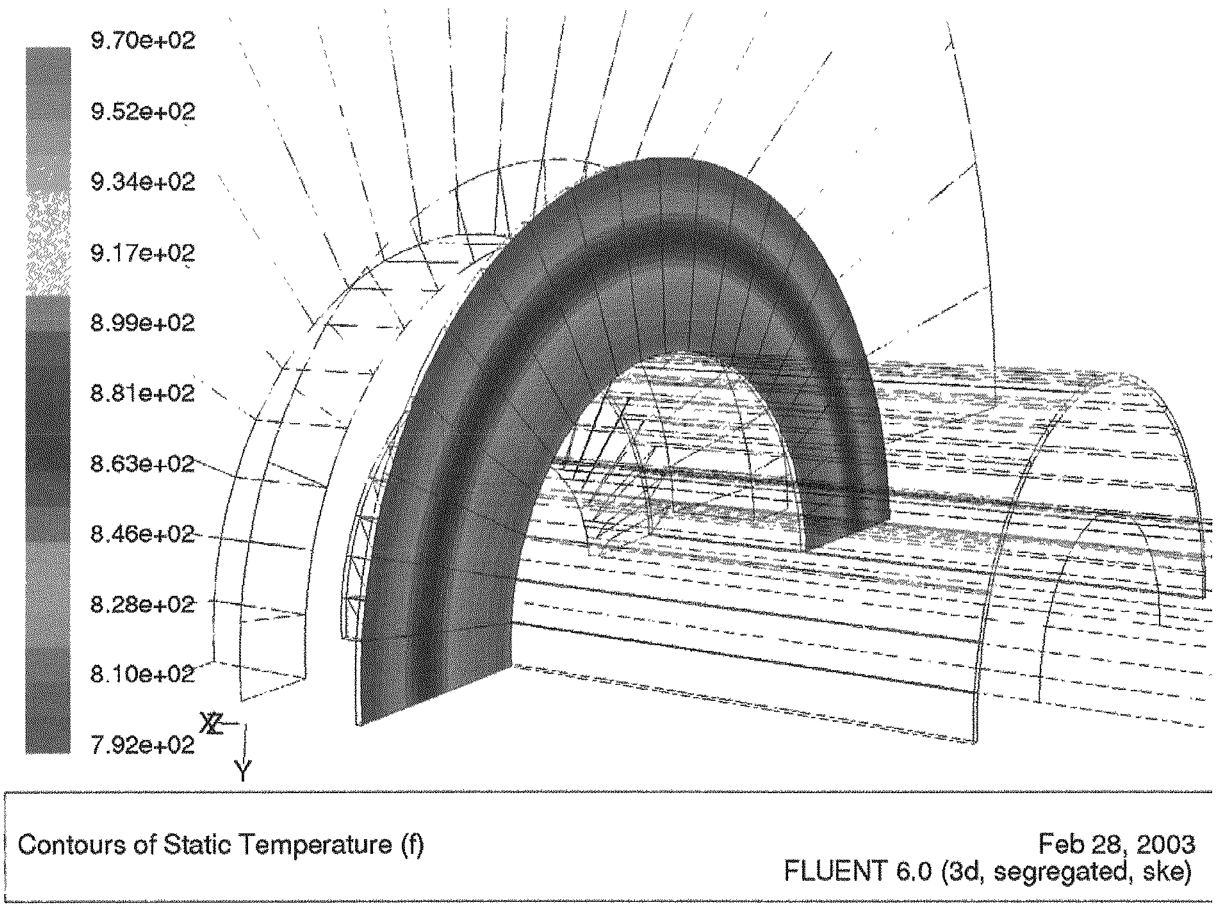

Figure 3-18. Burner in service rear wall wall temperature contours at 875 MW.

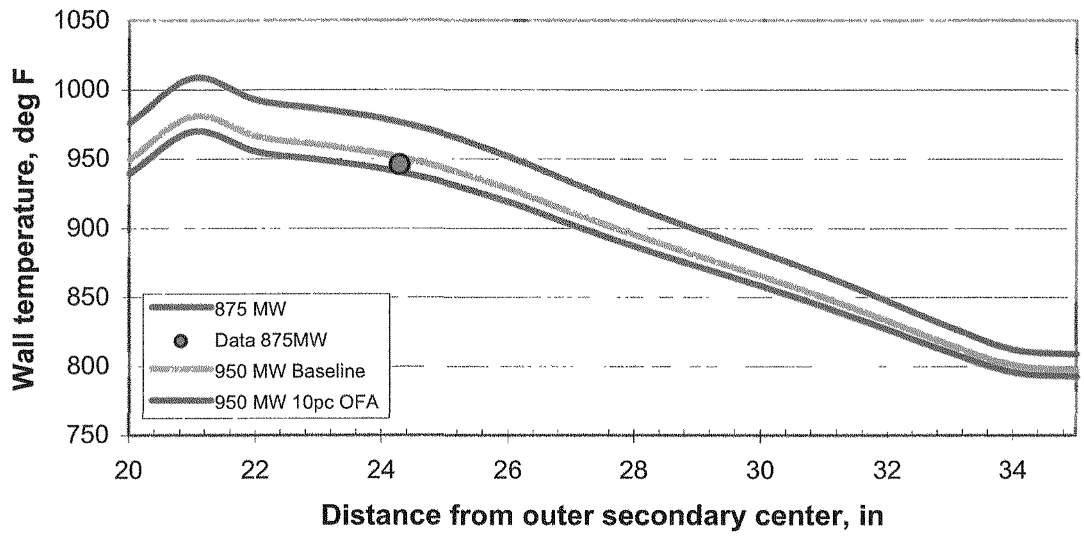

Figure 3-19. Wall temperature profile on the rear plate of the burner outer secondary flow duct with and without OFA (burner in service at 950 MW).

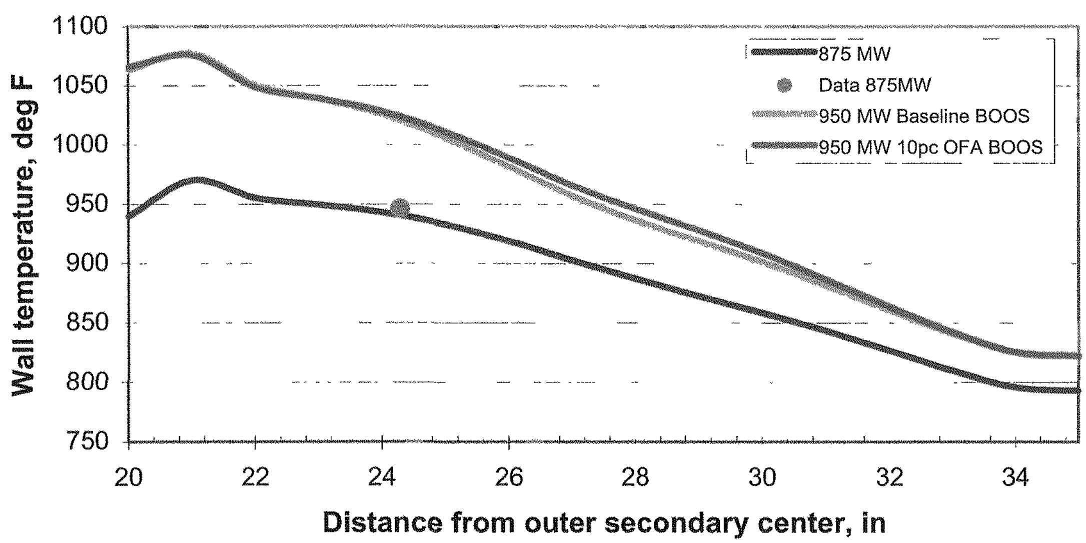

Figure 3-20. Wall temperature profile on the rear plate of the burner outer secondary flow duct with and without (burner out of service at 950 MW).

Figure 3-20 compares the baseline temperature profiles on the rear plate of the outer secondary air duct at original baseline conditions (875 MW) with those at uprated nominal load conditions (950 MW) with a burner out of service. IPSC has indicated that when they run burner out of service, they turn off the primary airflow and adjust the airflow rate to maintain all burner thermocouple measurement below a threshold value of 1125 °F. From the data, averaging all the temperatures in the out-of-service burner row, including one at 1132 °F results baseline maximum temperature of 1030 °F. Therefore, we elected to use 1030 °F temperature threshold to adjust the secondary airflow rate when a burner row is out of service. To maintain a 1030 °F threshold value at 10 percent OFA, the secondary airflow rate was set to 19 klb/hr. At this flow rate and nominal uprated load conditions with no overfire air, the figure shows that the wall temperature profile is nearly the same as that for original baseline conditions. At the same airflow rate, when 10 percent of the total air is shifted to the OFA injectors, the wall temperatures increase by less than 10 °F. This suggests that the impact of the higher gas source temperature on the burner metal temperatures during OFA operating conditions is relatively small and control of the surface temperatures can be maintained by adjusting the airflow rate.

In general, the burner CFD model predicts that the rear plate wall temperature distribution in the outer secondary airflow duct will probably not increase to dangerous levels during 10 percent OFA operating conditions when burners are either in service or out of service.

3.4 Conclusions

A furnace CFD model of the IGS furnace has been developed to investigate how OFA and platen superheater upgrades will affect local gas temperatures and compositions in the IGS steam generators. A burner CFD model has also been developed to predict burner metal temperatures during uprated nominal OFA operating conditions. Both models were calibrated using field data and results from the boiler thermal model discussed in Section 2 and Appendix 1 of this report.

The results of the furnace CFD model indicate that the furnace flow field is non-uniform, but typical of opposed wall-fired boilers. Upgrading the platen exchanger by adding additional surface area is expected to have a minor impact on the gas-side performance parameters evaluated, such as CO distribution. At 10 percent OFA, the OFA jets do not achieve deep penetration across the furnace cross section. Operation with the 1/3 damper closed results in a small improvement in OFA penetration. OFA mixing and CO oxidation continues as the flue gas enters the backpass; however, CO emissions are projected to nearly double with 10 percent OFA Biasing flow in the OFA injectors may help improve jet penetration and mixing effectiveness. Because the model projections show that concentration characteristics (e.g. CO) of the boiler map very well from the OFA to the backpass regions, OFA flow biasing can probably be adjusted using CO grid measurements at the economizer exit.

The results of the burner CFD model indicate that the rear plate wall temperature distribution in the outer secondary airflow duct does not increase to dangerous levels during 10 percent OFA operating conditions when burners are either in service or out of service. The primary reason that the burner-out-of-service operating scenario does not generate any additional thermal problems is because IPSC adjusts the airflow rate in the out-of-service burner to accommodate any changes in heating rates. IPSC has informed us that the flow may increase or decrease relative to in-service operation depending on which burner row is out-of-service. The model predicts that additional heating due to higher source temperatures under OFA conditions does not require a any increase in cooling airflow relative to that for baseline conditions. Therefore, maintaining burner wall temperatures below the current threshold values during OFA operating conditions should be readily handled with the current burner damper and monitoring systems.

4.0 NO_X Impact Analysis

A process model has been developed to project the impacts of overfire air on NO_X emissions for uprated nominal flow conditions (950 MW). The effect of different fuels on the NO_X emissions levels achievable with overfire air were also evaluated. The process model was based upon the unit design and fuel characteristics, the results of the modeling efforts described in Sections 2.0 and 3.0 of the report, and experience with the application of NO_X control technologies to coal-fired boilers.

The impacts of the unit operating load on NO_X emissions are summarized in Figures 4-1 and 4-2. In both cases, the data were obtained with one mill out of service. Figure 4-1 shows data for Unit 1 obtained in December 2002 at the original nominal load of approximately 875 MW. The plot shows NO_X and excess oxygen as a function of unit load. Average NO_X emissions at the original nominal load are approximately 0.38 lb/MMBtu. Figure 4-2 shows data for Unit 2 obtained in May of 2002 at the uprated nominal load of approximately 950 MW. As load is increased, the average NO_X emissions increased to approximately 0.44 lb/MMBtu. Comparison of the two data sets shows that the average oxygen level was approximately 1% lower for the higher load case. Operation at the higher excess air level at the uprated nominal load would be expected to result in increased NO_X emissions levels. Based upon the unit design and the properties of Fuel A, a process model of furnace was developed. The model showed good agreement with the data shown in Figures 4-1 and 4-2. This model was then used to project the impacts of overfire air operation on NO_X emissions.

The following sections discuss the impacts of overfire air operation on the unit NO_X emissions. Section 4.1 provides an introduction to low-NO_X burners and overfire air technologies. Section 4.2 discussions the project impacts of overfire air and fuels fired on NO_X emissions.

4.1 Low NO_X Burners and Overfire Air

Nitric oxide emissions from coal combustion are primarily formed through the oxidation of chemically bound nitrogen in the fuel, "fuel NO", and through the fixation of atmospheric

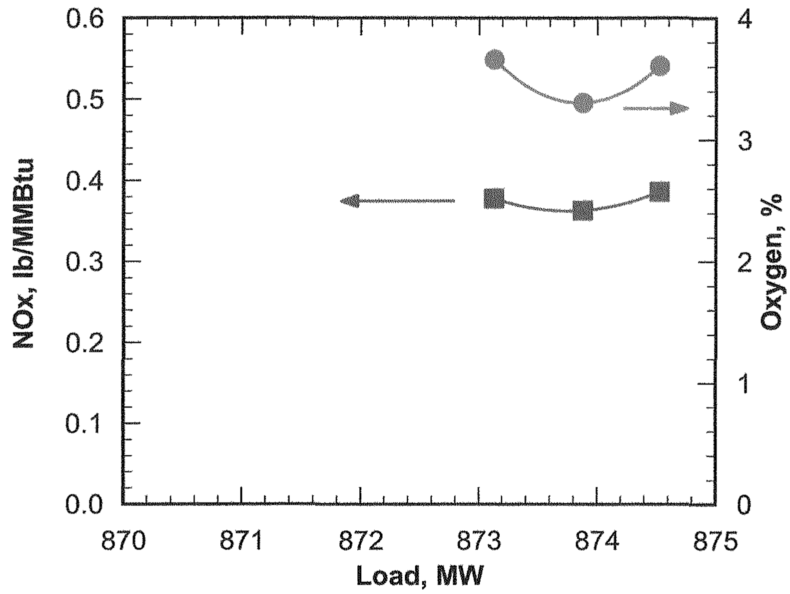

Figure 4-1. NO_X emissions data at original nominal load (875 MW).

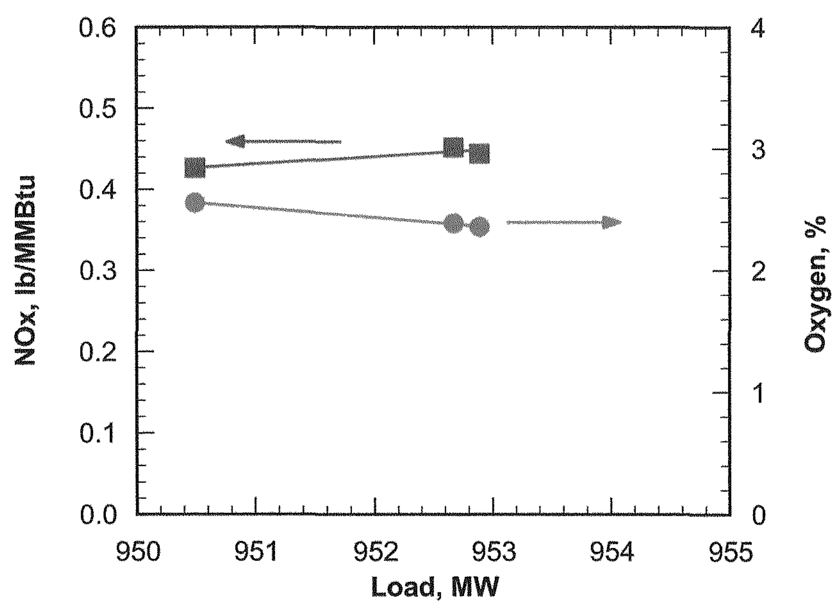

Figure 4-2. NO_X emissions data at uprated nominal load (950 MW).

nitrogen, "thermal NO". Of these two sources, fuel NO is the largest contributor to total NO emissions in typical coal flames. The conversion of fuel-bound nitrogen into nitric oxide is sensitive both to the coal characteristics and to the local environment that the nitrogen bearing species encounter upon release from the coal. Evolution of fuel-bound nitrogen under fuel rich conditions reduces its potential for conversion to NO.

Low-NO_X burners reduce NO_X formation in the combustion process by delaying the mixing of fuel and air in the flame. One means of aerodynamically staging fuel and air mixing in a coal flame is illustrated in Figure 4-3. In this low-NO_X burner design, the mixing of fuel and air is controlled by dividing the combustion air into multiple streams, with separate control over each stream. Coal entering the flame is initially burned in a fuel rich core that gradually becomes fuel lean as air is progressively mixed into the flame. Staging of the air into the flame permits volatile nitrogen compounds released in the early portion of the flame to be processed in a reducing environment, resulting in lower NO_X emissions.

The performance of low-NO_X burners in a particular application is very dependent upon the boiler and coal characteristics. One parameter often used to illustrate the effect of boiler design parameters is the 'burner zone heat liberation rate', which relates total firing rate to the surface area of a hypothetical box defining the burner zone. Figure 4-4 shows the use of a 'burner area heat release' (BAHR) parameter to correlate NO_X emissions data from different units. Data are shown for units with and without low-NO_X burners. The trend lines drawn on the figure show both the influence of BAHR on NO_X emissions and the range of NO_X emissions that might be expected from low-NO_X burners. Within this range, the performance of a burner, at a given BAHR, is impacted by a number of boiler specific factors such as the available firing depth, coal type, and particularly by the flexibility offered within existing burner openings in the boiler wall.

For the IGS units, the BAHR at 875 MW is estimated as 273,000 Btu/ft^2-hr and at 950 MW is estimated as 306,000 Btu/ft^2-hr. The average NO_X emissions for the units at these loads are plotted in Figure 4-4. The measured NO_X emissions appear to correlate well with the BAHR parameter and lend confidence to the process model used to predict the effects of overfire air. The comparison also suggests that the current low-NO_X burners are performing well.

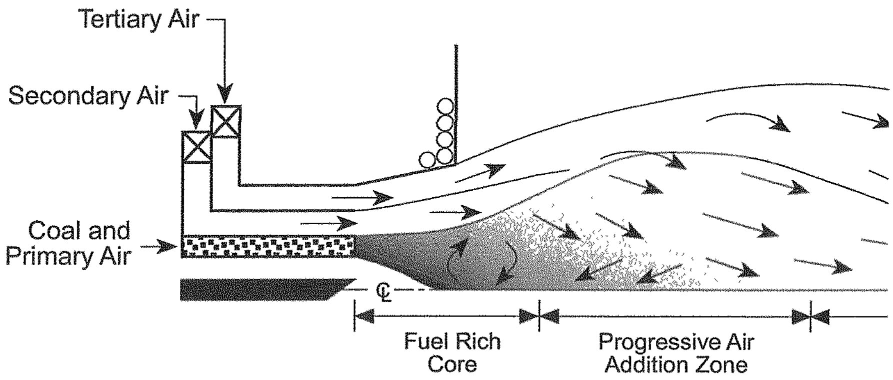

Figure 4-3. Schematic of fuel and air staging in a low NO_X burner.

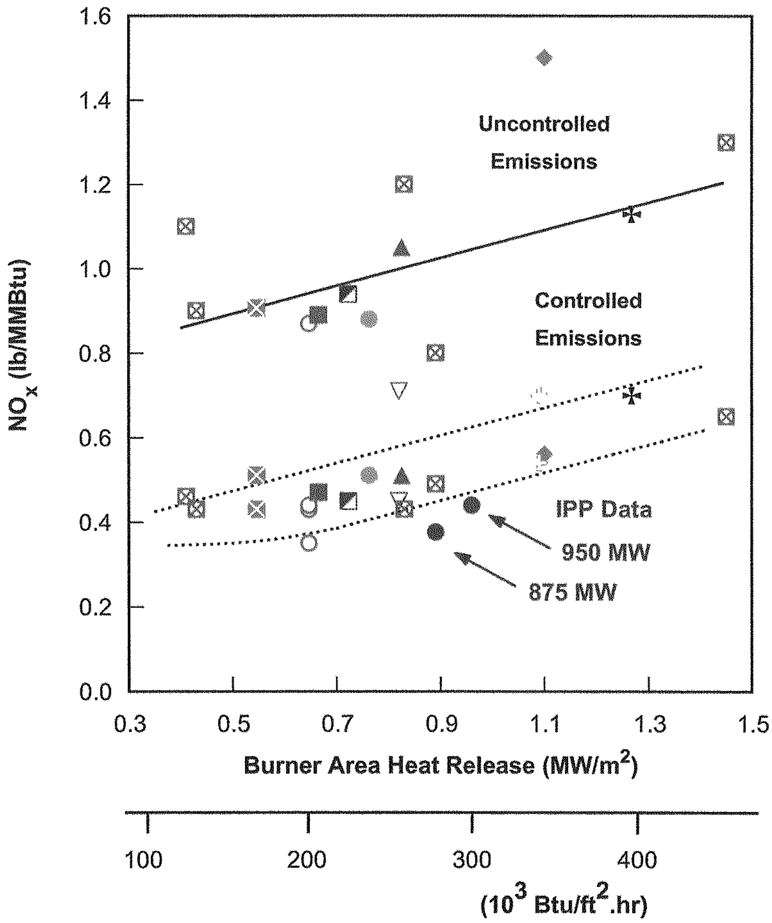

Figure 4-4. NO_X emissions as a function of the burner area heat release (BAHR) parameter.

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Overfire air, like low-NO_X burners, stages the combustion process to reduce NO emissions. To apply overfire air to a coal-fired boiler, combustion air is diverted from the main combustion zone and is injected through ports located on the walls above the burners. In this process, the primary zone is operated slightly less fuel lean than usual, and fuel and air mixing is delayed. This delay reduces the formation of fuel NO. Overfire air is added to complete combustion of unburned fuel.

For pulverized coal-fired boilers, the performance of overfire air is dependent upon the overfire air system design and the burner/boiler characteristics. Optimal NO_X control for a particular system can be achieved provided that the overfire air jets mix effectively, that good control over the main flame can be maintained as combustion air is diverted to the overfire air system, and that there is sufficient residence time in the furnace for carbon burnout to occur. As with low-NO_X burners, the NO_X control performance of overfire air is limited by acceptable carbon-in-ash. Good mixing of the overfire air is also required to minimize the effects of overfire air operation on CO emissions.

4.2 NO_X Emissions Projections

A process model was developed for the IGS units. The model takes into account the furnace geometry, the current low-NO_X burners and other parameters. Based upon the characteristics of Fuel A, the process model predicted a NO_X emissions level of 0.39 lb/MMBtu for an operating load of 875 MW and of 0.44 lb/MMBtu for an operating load of 950 MW. The predictions were in good agreement with the baseline data.

Figure 4-5 shows the projected impacts of overfire air on NO_X emissions at both the original nominal load (875 MW) and the uprated nominal load (950 MW). At the uprated nominal load, operation with 7% overfire air is expected to reduce NO_X emissions levels to the current level of 0.38 lb/MMBtu. Operation with 10% overfire air is projected to reduce NO_X emissions to a level of approximately 0.36 lb/MMBtu. These results have been corroborated with a fuel NO_X emissions simulation using the FLUENT CFD Model described in Section 3.0.

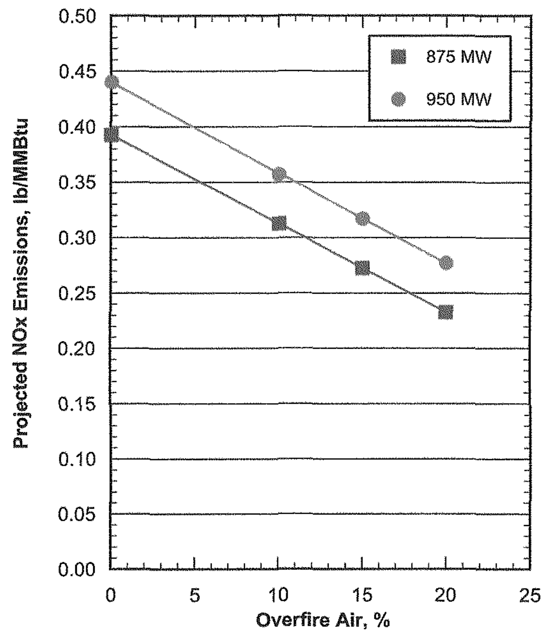

Figure 4-5. Predicted Fuel A NO_X emissions for OFA at different loads.

The projected impacts of the different fuels fired on NO_X emissions with and without overfire air are shown in Figure 4-6. In comparison to Fuel A, the combustion of Fuels B-E is expected to result in higher NO_X emissions due to the differences in fuels characteristics. Therefore, it is expected that higher levels of overfire air will be required when firing these fuels in order to minimize their impact on the unit NO_X emissions.

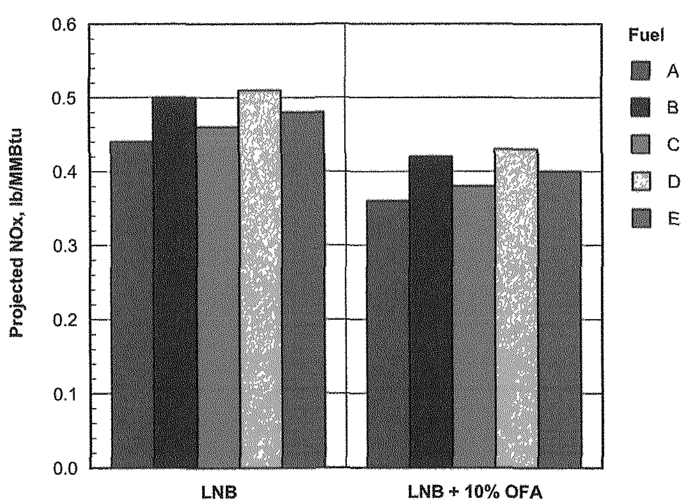

Figure 4-6. Predicted NO_X emissions for different fuels at 950 MW load conditions.

From: <csimmons@bbpwr.com>
To: <JIM-N@ipsc.com>
Date: 11/11/02 2:30PM
Subject: 501080-Intermountain Power

James,

Please find the drawing you requested attached in the E-mail below.
----- Forwarded by Chris Simmons/Riley/US on 11/11/2002 04:05 PM -----

Matt Scricco

To: Chris Simmons/Riley/US@Riley

11/11/2002 cc: Paul Bloom/Riley/US@Riley

01:46 PM Subject: 501080-Intermountain Power

(See attached file: PP-501080-10-00.dwg)

From: <larry.swanson@ps.ge.com>
To: <jim-n@ipsc.com>
Date: 2/6/03 4:16PM
Subject: IPP presentations: Furnace CFD Results and NOx Predicitons

<<CFD Furnace Model 4-Feb-03.ppt>> <<NOx Analysis 4-Feb-03.ppt>>

> g GE Power Systems
Energy and Environmental Research Corp.

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Subject: IPP presentations: Introduction and Boiler Thermal Model Results

<<Intro Summary 4-Feb-03.ppt>> <<Boiler Thermal Model 4-Feb-03.ppt>>

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OFA Flowmeter List
Jerry Finlinson
These are all located on the boiler 9th level

1SGB-FT-155	OFA SW Inlet Flow
1SGB-FT-156	OFA SE Inlet Flow
1SGB-FT-157	OFA NW Inlet Flow
1SGB-FT-158	OFA NE Inlet Flow
2SGB-FT-155	OFA SW Inlet Flow
2SGB-FT-156	OFA SE Inlet Flow
2SGB-FT-157	OFA NW Inlet Flow
2SGB-FT-158	OFA NE Inlet Flow

Air Monitor CAMS system w/ Volu-probe/2SS traverse air flow probe
Air Monitor CAMS system w/ Volu-probe/2SS traverse air flow probe
Air Monitor CAMS system w/ Volu-probe/2SS traverse air flow probe
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Air Monitor CAMS system w/ Volu-probe/2SS traverse air flow probe
Air Monitor CAMS system w/ Volu-probe/2SS traverse air flow probe
Air Monitor CAMS system w/ Volu-probe/2SS traverse air flow probe
Air Monitor CAMS system w/ Volu-probe/2SS traverse air flow probe

BOILER MODIFICATION BID PACKAGE EVALUATION		
Bid Items	**Babcock & Wilcox**	**Babcock Borsig**
No. of OFA Ports	13 ports total 7 front, 6 rear	16 ports total 6 front, 6 rear, 4 corner
Degree of Automation	Dampers Actuated	Dampers Actuated
Port Instruments	Magnahelic dP guages on each port Pitot air flow monitors on each port	Magnahelic dP guages on each port. Pitot air flow monitors on each port
Platen Superheat Surface	Quoted as specified	Quoted as specified
Boiler Scaffold	Quoted as specified	Quoted as specified
Outage Schedule	Option 1 - 28.5days (OFA w/platens) Option 2 - 26 days (OFA w/o platens)	Option 1 - 25 Days w/platens Option 2 - 21 Days w/o platens
Technical Support	2 weeks during startup 1 week performance testing	2 weeks during startup 2 weeks during initial operation 1 week performance testing
Modeling Cost	B&W feels they have done enough modeling on our boiler to warrant no further model work	$31,987
Scaffold Cost	Quoted as deduct only U1($266,357) U2($272,905)	U1 $411,693 U2 $432,993
OFA System Cost	U1$3,403,823 U2 $3,419,172	U1 $2,535,451 U2 $2,444,778
Platen Superheat Surface Cost	U1 $1,155,369 U2 $1,283,871	U1 $1,160,629 U2 $1,071,052
Superheat Casting Installation Cos	U1 $85,000 U2 $90,000	U1 $129,736 U2 $135,838
Technical Support Cost	In Bid	U1 $87,864 U2 $87,748
Performance Guarantees	**No Guarantees** but confident in achieving 1005F steam temps and 15% NOx reduction	37 lbs/MMBTU Nox Agreed to all related performance test parameters
Liquidated Damages Offered	Offering $10K per day after first 30 days of delay only Of essentially no contractual value	Complying with all four liquidated damage clauses at $50K per day.
Total Modification Cost*	OFA + Platens $9,437,235 OFA only $6,822,995	OFA + Platens $8,529,769 OFA only $6,298,088

* Includes scaffold, technical support, labor, materials and modeling as applicable to each approach for each bid.

Alstom
NO BID

From: "Bernstein, Gary S" <gsbernstein@babcock.com>
To: <JIM-N@ipsc.com>, <ralph-n@ipsc.com>
Date: 8/21/02 2:03PM
Subject: IPSC Boiler Modifications Summary of B&W and IPSC August 20, 2002teleconference B&W Proposal No. P-003111

James/Ralph,

Please reference attached letter that summarizes the teleconference between James Nelson and B&W yesterday. The letter also includes our response to James' questions.

Looking forward to further discussions.

Regards,

Gary S. Bernstein, P.E.
District Sales Manager
Babcock & Wilcox

<<IPSC Clarifications_GSB-008.doc>>

CC: "Tedrow, Robert L" <rltedrow@babcock.com>, "Kleisley, Roger J" <rjkleisley@babcock.com>, "Willman, William A" <wawillman@babcock.com>, "Wewer, Robert W" <rwwewer@babcock.com>

INTERMOUNTAIN POWER SERVICE CORPORATION

☒ REQUISITION FOR CAPITAL EQUIPMENT

☐ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Date:	
Req./PA No:	185885
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Purpose of Materials, Supplies or Services:

Over Fired Air wind box duct installation interfered with existing HVAC duct work (west side of the boiler between the 9th and 10th floors). This requisition is for fabrication and delivery of HVAC duct work required for rerouting. Amount will be back charged.

Suggested Vendor: KOL FAB
716 West 300 South
Salt Lake City, UT 84104

Account No. 1SGX-402
Work Order No. 02-60456
Project No. IGS02-14

Qty	Unit	Description Noun / Adjective / Catalog # / Seller or Manufacturer	Unit Cost	Extension
1	ea	Duct work as shown on attached sketches and		$6,187.00
		quotation. Fabrication only.		
		1) 36"/72" Turning Vane Set		
		2) 30"/68" Rectangular Duct Section		
		3) 30"/68" Rectangular 90 deg Elbow		
		4) 68/30" Square to Round Transition		
		5) 46" Round 90 deg Elbow (12" Throat)		
		6) End Cap (Flat Sheet Sized to Existing Duct)		
		All Duct to be made of 10 GA Galvanized.		
		Guaranteed delivery by 10:00 AM on 3/25/03		
		if PO supplied by 7:00 AM on 3/19/03		
		TOTAL ESTIMATED COST		$6,187.00

Remarks:

Delivery requested by [Date] 3-25-03 Originator Bret Kent

Dept. Mgr/Supt. Date Station Manager Date Operating Agent Date

IP7_037300

Spec. XXXXX

LIST OF SUGGESTED BIDDERS

TABLE OF CONTENTS

SPECIFICATIONS

PART A - DIVISION A1

NOTICE INVITING PROPOSALS

The Intermountain Power Service Corporation (IPSC) invites sealed bids for **design, supply, installation, and removal of boiler scaffolding on Units 1 & 2** in accordance with **Specifications** ______, available in the Purchasing Section, Intermountain Power Service Corporation, 850 West Brush Wellman Road, Delta, UT 84624-9546.

Proposals shall be submitted on IPSC's bidding forms. All Proposals shall be filed with the Buyer at the above address on or before ______________.

Each Proposal shall be accompanied by a certified or cashier's check or a surety bond in the amount of ten (10) percent of the aggregate sum of the Proposal as a guarantee that the bidder shall execute the proposed Contract if awarded.

Proposals shall be subject to acceptance within, and irrevocable for, a period of ninety (90) calendar days after date of bid opening.

The right is reserved to reject any and all Proposals.

The successful bidder shall furnish a Performance Bond equal to ten (10) percent of the estimated Contract amount.

In the performance of any Contract awarded, the bidder shall not discriminate in employment practices against any employee or applicant for employment because of race, religion, national origin, ancestry, sex, age, or physical disability.

Dated: ______________________________

____
Buyer

PART B - DIVISION B1

INSTRUCTIONS TO BIDDERS

1. Form, Signature, and Delivery of the Proposals: The bidder's Proposal shall be made on the yellow copy of the Bidding Documents. The specifications printed on white paper shall be retained by the bidder.

   The bidder's name, address, and the date shall be stated in the Proposal. The Proposal shall be signed by the person authorized to bind the bidder.

   The Proposal shall be enclosed in a sealed envelope, plainly marked in the upper left-hand corner with the name and address of the bidder. The envelope shall bear the words "Proposal for," followed by the specifications number, the title of the specifications, and the date and hour of bid opening.

   If the Proposal is mailed, it shall be addressed as follows:

   Purchasing Section
   Intermountain Power Service Corporation
   850 West Brush Wellman Road
   Delta, UT 84624-9546

   If the Proposal is sent by messenger, it shall be delivered to the Administration Building, Intermountain Power Service Corporation, 850 West Brush Wellman Road, Delta, UT.

2. Interpretations and Addenda: Should a bidder find discrepancies or omissions in the plans, specifications, or other documents, or should there be doubt as to their true meaning, the bidder shall submit to the Buyer a written request for an interpretation or clarification thereof. A request for addenda, interpretation, or clarification shall be delivered to the Buyer marked "Request for Interpretation" and will be received by the Buyer in time to permit a reasonable response before date of bid opening. Any interpretation of, or change in the documents will be made only by addendum issued to each person to whom specifications have been issued and will become a part of any contract awarded. IPSC will not be responsible for any other explanations or interpretations.

3. Correspondence: All inquiries or correspondence to IPSC prior to award of the Contract shall be addressed to the Buyer.

4. Changes or Alternatives: The bidder shall not change any wording in the documents. Any explanations or alternatives offered shall be submitted in a letter attached to the front of the Bidding Documents. Alternatives which do not substantially comply with IPSC's specifications cannot be considered. Language of negation or limitation of any rights, remedies, or warranties provided by law will not be considered part of the Proposal. Bids offered subject to conditions or limitations may be rejected.

5. Specified Materials or Equivalent: Whenever any particular material or process is specified by a patent or proprietary name, by a trade or brand name, or by the name of a manufacturer, such wording is used for the purpose of describing the material or process, fixing the standard of quality required, and shall be deemed to be followed by

the words "or equivalent." The bidder may offer any material or process which shall be the equivalent of that so specified.

6. Language: Everything submitted by the bidder shall be written in the English language.

7. Sales or Use Taxes: Prices quoted by the bidder shall not include any applicable sales or use taxes or Federal Excise Taxes.

8. Duties: Prices quoted by the bidder shall include all applicable duties.

9. Award of Contract: Any award of Contract will be made to the lowest and best, regular responsible bidder. The determination as to which is the lowest and best, regular responsible bidder may be made on the basis of the lowest ultimate cost of the materials or equipment in place and use. The right is reserved to reject any or all Proposals.

   Within thirty (30) calendar days after the date of award of Contract, the successful bidder shall sign the Contract supplied by IPSC. The Contract will be effective upon execution by IPSC.

10. Comparison of Bids: Bid comparison will be based on the lowest ultimate cost and the Contractor's experience in similar jobs.

11. Bidder's Bond: The Proposal shall be accompanied by a certified check or a cashier's check issued by a responsible bank, payable in the state of Utah to the order of Intermountain Power Agency, in an amount not less than ten (10) percent of the aggregate sum of the Proposal. A surety bond in a like amount will be accepted in lieu of a check.

    The surety bond shall be submitted on IPSC's Bidder's Bond form. The check or bidder's bond shall be enclosed in the same envelope with the Proposal.

12. Performance Bond: Within thirty (30) calendar days after date of award of Contract, the successful bidder shall furnish a Performance Bond equal to ten (10) percent of the estimated amount of the Contract.

13. Calculation of the Bonds: The estimated amount of the Proposal for the Bidder's Bond or of the Contract for the Performance Bond will be considered to be the price, including freight charges, quoted by the bidder in the Proposal Schedule, times the assumed quantity under the Comparison of Bids in Article 10 of this Division.

14. Bid Evaluation Credit: A bid evaluation credit of $100,000 per day shall be applied to each applicable bid for each full day less than the longest installation schedule bid in the respective, proposed Installation Plan. Bid evaluation credit shall not apply to the longest schedule bid. This is a bid evaluation credit only and shall not modify or supersede any part of the submitted bid package.

PART C - DIVISION C1

BIDDING DOCUMENTS

BIDDER'S BOND

(Not necessary when check accompanies bid. See below*.)

SURETY BOND

We, the undersigned principal and surety, acknowledge ourselves jointly and severally bound to Intermountain Power Agency (IPA) and Intermountain Power Service Corporation (IPSC) of the state of Utah, and the city of Los Angeles Department of Water and Power, in the sum of ____ Dollars ($__________), to be paid to IPA if the attached Proposal shall be accepted and the proposed Contract awarded to said bidder, and said bidder shall fail to execute the Contract and bond for the faithful performance thereof; otherwise this obligation to be void.

Dated: ________________________________, 20 ________

Firm Name: ____

____

By: ____
(Signature)**

(Surety): ____

By: ____
(Signature)

*Where bidder is submitting a check in lieu of a bond, the check must be made payable to IPA and must be either certified by a responsible bank or be a cashier's check issued by a responsible bank and payable in the state of Utah.

If check is submitted herewith, state number ________________ and amount $___________.

**See Signatures, Division B1

NOTE: All signatures above must be written in ink.

PROPOSAL

The undersigned hereby proposes to furnish and deliver manpower and material to the Intermountain Power Service Corporation in accordance with **Specifications** ______

The undersigned agrees, upon the acceptance of this Proposal, to enter into and execute a Contract consisting of the documents identified in Part D of said Specifications for furnishing and delivering the items embraced in the accepted Proposal at the prices named in the accompanying Proposal Schedule and to execute a bond conditioned upon the faithful performance of the Contract.

The undersigned furthermore agrees that, in case of failure to execute such Contract and provide the necessary Performance Bond, the check or Bidder's Bond accompanying this Proposal and the monies payable thereon shall be forfeited to and remain the property of the Intermountain Power Agency.

The undersigned declares under penalty of perjury that such Proposal is genuine, and not sham or collusive, nor made in the interest or in behalf of any person or entity not herein named, and that the bidder has not directly or indirectly induced or solicited any other bidder to put in a sham bid, or any other person, firm, or corporation to refrain from bidding, and that the bidder has not in any manner sought by collusion to secure for itself an advantage over any other bidder.

I declare under penalty of perjury under the laws of the state of Utah that the foregoing is true and correct.

Date: ______________________________, 20 ________

Bidder: ____

Address: _______________________________________

____

Signed By: _____________________________________
(Authorized Signature)

Print Name: ____________________________________

Title: ____

LABOR, MATERIAL, AND PERFORMANCE BOND

1. Know all persons by these presents, that

____

(Insert Contractor's name and address or legal title.)

____

as Principal, hereinafter called Contractor, and

____

as Surety, hereinafter called Surety, are held and firmly bound unto Intermountain Power Agency, Intermountain Power Service Corporation, hereinafter called IPSC, and the city of Los Angeles Department of Water and Power, as Obligee, in the amount of ____________________________ Dollars ($_________) for the payment whereof Contractor and Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

2. WHEREAS, Contractor has by written agreement dated

______________________, 20________, entered into a Contract with IPSC for

____

____

in accordance with Contract No. _________ which Contract is attached hereto and by reference made a part hereof, and is hereinafter referred to as the Contract.

NOW, THEREFORE,

3. THE CONDITION OF THIS OBLIGATION is such that, if Contractor shall promptly and faithfully perform said Contract, and shall promptly make payment to all claimants for labor and material used or supplied for use in the performance of the Contract, then this obligation shall be null and void; otherwise, it shall remain in full force and effect.

4. Whenever Contractor shall be, and declared by IPSC to be, in default under the Contract, IPSC having performed IPSC's obligations thereunder, the Surety may promptly remedy the default, or shall promptly:

   a. Complete the Contract in accordance with its terms and conditions, or

   b. Obtain a bid or bids for submission to IPSC for completing the Contract in accordance with its terms and conditions, and upon determination by IPSC and Surety of the lowest responsible bidder acceptable to IPSC, arrange for a

Contract between such bidder and IPSC, and make available as work progresses (even though there should be a default or a succession of defaults under the Contract or Contracts of Completion arranged under this paragraph) sufficient funds to pay the cost of completion less the balance of the Contract price, but not exceeding the amount of the bond. The term "Balance of the Contract price," as used in this paragraph, shall mean the total amount payable by IPSC to Contractor under the Contract and any amendments thereto, less the amount previously paid by IPSC to Contractor.

5. Upon failure of Contractor to timely pay laborers and material men, Surety agrees to discharge such obligation in an amount not exceeding the sum set forth above and also, in case suit is brought upon this bond, a reasonable attorney's fee to be fixed by the court. *This bond shall inure to the benefit of any and all persons named in Title 14,* Chapter 2, Utah Code, as amended, so as to give a right of action to such persons or their assigns in any suit brought upon this bond.

6. No right of action shall accrue on this bond to or for the use of any person or corporation other than named herein, or the heirs, executors, administrators, or successors and assigns of IPSC, except as provided by statutory or regulatory provisions relating to Contractor's bonds upon public and private contracts, the provisions of which are made a part thereof as a supplemental description of the Surety's obligations herein.

7. The Surety hereby waives notice of any change orders or extensions of time made by IPSC in accordance with the terms of the Contract.

8. SIGNED AND SEALED this ____________ day of _________________ A.D. 20_____

In the presence of: ____
(Principal)

(Seal)

______________________________	______________________________
(Witness)	(Title)

(Seal)

	______________________________
	(Surety)

______________________________	______________________________
(Witness)	(Title)

PART C - DIVISION C2

BIDDING DOCUMENTS - PROPOSAL SCHEDULE

Proposal is hereby made to furnish and deliver to IPSC manpower and material as required for **design, supply, installation, and removal of boiler scaffolding on Units 1 & 2,** F.O.B. Intermountain Power Service Corporation, 850 West Brush Wellman Road, Delta, UT, in accordance with **Specifications XXXXX**,and the following:

Bid Submittals: Each bidders shall include the following information with their bid:

a. Engineering, Material & Delivery Schedule

b. Proposed Installation Plan (See Section 4.0)

c. Proposed Subcontractor List (including contacts, references and phone #s.) All subcontractors shall be approved by the Contract Administrator prior to mobilization.

d. Bidders shall submit a required access plan showing location and extent of all lay-down and staging.

Prices: Bidders shall complete and submit the following pricing schedule. Prices are to be stand-alone, line item pricing unless specified otherwise by the bidder or indicated otherwise within the following line items.

ITEM	BID Unit 1	BID Unit 2
Design, procure, deliver, install and remove a complete scaffold structure for all applicable boiler internal work on Units 1 & 2. Unit 1 beginning 3/1/2003 and Unit 2 beginning 2/28/2004. (Unit 2 procurement release contingent upon successful installation of Unit 1. Boiler internal scaffold is detailed within the attached specification)..	__________	__________

Cash Terms: A discount for prompt payment is offered of ____________ percent for Contract payments made within ___________ calendar days after date of acceptance or delivery and receipt of invoice.

Taxes: The foregoing quoted prices are exclusive of all applicable sales and use taxes.

Form of Business Organization: The bidder shall state below the form of its business organization.

Bidder is: ____________________________ (Corporation, Partnership, Limited Partnership, Individual)

If a partnership, the bidder shall state below the names of the partners. If a corporation, the bidder shall state below the names of the president and of the secretary.

____________________________ ____________________________

____________________________ ____________________________

Person to Contact: Should IPSC desire information concerning this Proposal, please contact:

Name: ________________________ Telephone No: ____________________

Address: ____

PART D - DIVISION D1

CONTRACT DOCUMENTS

The documents listed in the Table of Contents, the reference specifications, any documents listed below, and the bidding documents as expressly agreed to by IPSC shall constitute the Contract. Said documents are complementary and require complete and finished work. Anything shown or required of the Contractor in any one or more of said documents shall be as binding as if contained in all of said documents. The Contractor shall not be allowed to take advantage of any error, discrepancy, omission, or ambiguity in any document, but shall immediately report to the Chief Operations Officer, in writing, any such matter discovered. The Chief Operations Officer will then decide or correct the same and the decision will be final.

Drawings: The following drawings are being provided for reference purposes only. Dimensions on these drawings are not guaranteed by IPSC.

Dwg. Name
950 MW Unit Test Data (Excel File)
Boiler Buckstays
Boiler Front Wall
Boiler Loading Diagram (Sheet 1)
Boiler Loading Diagram (Sheet 2)
Boiler Plan View
Boiler Front Wall (Sheet 1)
Boiler Front Wall (Sheet 2)
Boiler Side Elevation
Boiler Structural Steel (South)
Furnace Front Wall Panel
Secondary Superheat Inlet
Secondary Superheat Platen
Burner Port (60A)
Corner Insulation (40N)
Corner Port Insulation (44G)
Insulation Key
Insulation Specification
Waterwall Insulation (45H)
Windbox Insulation (ITP4.0)
Windbox Insulation (MTP4.0)

Drawings prepared by the Contractor for this project shall be submitted to the Owner for review prior to commencement of fabrication. Required drawing might include, but are not limited to, details of any an all hard connections to boiler wall and required access points. This review shall not relieve the successful bidder of sole responsibility for the adequacy and correctness of the associated work. All project drawings shall be stamped by a registered professional engineer, licensed within the state of Utah

PART E - DIVISION E1

GENERAL CONDITIONS

1. Definitions: The following words shall have the following meanings:

   a. Bidder: The person, firm, or corporation adopting and submitting a Proposal under these specifications.

   b. Buyer: The Purchasing Agent for IPSC.

   c. Chief Operations Officer: The President and Chief Operations Officer of IPSC or designated representatives acting within the limits of their authority.

   d. Contract Administrator: The IPSC employee designated by the Chief Operations Officer with primary responsibility for administration of the Contract or designated representatives acting within the limits of their authority.

   e. Contractor: The person, firm, or corporation to whom the Contract is awarded.

   f. Directed, Required, Approved, etc.: The words *directed, required, approved, permitted, ordered, designated, prescribed, instructed, acceptable, accepted, satisfactory*, or similar words shall refer to actions, expressions, and prerogatives of the Contract Administrator unless otherwise expressly stated.

   g. Gallon: Liquid volume of 231 cubic inches at 60 degrees Fahrenheit.

   h. IPA: Intermountain Power Agency, the owner of IPP, and a political subdivision of the state of Utah, organized and existing under the Interlocal Co-operation Act, Title 11, Chapter 13, Utah Code Annotated 1953, as amended.

   i. IPP: Intermountain Power Project, consisting of Intermountain Generating Station, Intermountain Railcar, Intermountain Converter Station, Adelanto Converter Station, Intermountain AC Switchyard and associated transmission lines, microwave stations, and support facilities.

   j. IPSC: Intermountain Power Service Corporation, a nonprofit corporation, furnishing personnel to support the Operating Agent in the performance of operation and maintenance.

   k. Operating Agent: The city of Los Angeles Department of Water and Power (LADWP) which is responsible for operation and maintenance for IPP.

   l. Reference Specifications: Those bulletins, standards, rules, methods of analysis or tests, codes, and specifications of other agencies, engineering societies, or industrial associations referred to in these specifications. These refer to the latest edition, including amendments published and in effect at the date of advertising these specifications, unless specifically referred to by edition, volume, or date.

m. Subcontractor: A person, firm, or corporation, other than the Contractor and employees thereof, who supplies labor or materials on a portion of the work.

n. Ton: The short ton of 2000 pounds.

2. Materials and Work: All materials and work shall comply with these specifications. All materials and equipment furnished shall be new and unused, but this requirement shall not preclude the use of recycled materials in the manufacturing processes. All work shall be done by qualified workers in a thorough and workmanlike manner. Materials or workmanship not definitely specified, but incidental to and necessary for the work, shall conform to the best commercial practice for the type of work in question.

3. Nondiscrimination: The applicable provisions of Executive Order No. 11246 of September 24, 1965, and Bureau of Land Management regulations pertaining to nondiscrimination in employment in the performance of contracts, are incorporated herein by reference, and made a part hereof as if they were fully set forth herein. During the performance of this Contract, the Contractor shall not discriminate in its employment practices against any employee or applicant for employment because of the employee's or applicant's race, religion, national origin, ancestry, sex, age, or physical disability. All subcontracts awarded under any such contract shall contain a like nondiscrimination provision.

4. Governing Law: This Contract shall be governed by the substantive laws of the state of Utah, regardless of whether rules on the conflict of laws would cause a court to look to the laws of any other state or laws of any other jurisdiction. Any action, in law or in equity, concerning any alleged breach of or interpretation of this Contract, or concerning any tort in relation to this Contract or incidental to performance under this Contract, shall be filed only in the state or federal courts located in the state of Utah.

5. Patents and Intellectual Property: The Contractor shall fully indemnify IPSC, IPA, and the Operating Agent against any and all liability, whatsoever, by reason of any alleged infringement of any intellectual property rights (including, but not limited, to patents, copyrights, trademarks, or trade secrets) on any article, process, method, or application used in any designs, plans, or specifications provided under this Agreement or by reason of use by IPSC of any article or material specified by the Contractor.

6. Contractor's Address and Legal Service: The address given in the Proposal shall be considered the legal address of the Contractor and shall be changed only by written notice to IPSC. The Contractor shall supply an address to which certified mail can be delivered. The delivery of any communication to the Contractor personally, or to such address, or the depositing in the United States Mail, registered or certified with postage prepaid, addressed to the Contractor at such address, shall constitute a legal service thereof.

7. Assignment of Contract Prohibited: The Contractor shall not assign or otherwise attempt to dispose of this Contract, or of any of the monies due or to become due thereunder, unless authorized by the prior written consent of the Chief Operations Officer. No right can be asserted against IPSC, IPA, or the Operating Agent, in law or equity, by reason of any assignment or disposition unless so authorized.

If the Contractor, without such prior written consent, purports to assign or dispose of the Contract or of any interest therein, IPSC, at its option, may terminate the Contract, and IPSC, IPA, and the Operating Agent will be relieved and discharged from any and all liability and obligations to the Contractor, and to any assignee or transferee thereof.

8. Quality Assurance: The Contract Administrator has the right, but not the obligation, to subject any or all materials or equipment furnished and delivered under the Contract to rigorous inspection. Before offering any material or equipment for inspection or testing, the Contractor shall eliminate all items which are defective or do not meet the requirements of the specifications. If any items or articles are found not to meet the requirements of the specifications, the lot, or any faulty portion thereof, may be rejected. The fact that the materials or equipment have, or have not, been inspected, tested, or accepted by the Contract Administrator shall not relieve the Contractor of responsibility in case of later discovery of flaws or defects.

   Any materials testing at the jobsite that is required to determine suitability of materials within this contract, over and above visual inspection of materials and documentation , shall be charged against the contractor.

9. Extra Work or Changes by IPSC: IPSC reserves the right at any time before final acceptance of the entire work to order the Contractor to perform extra work, furnish extra material or equipment, or to make changes altering, adding to, or deducting from the work, without invalidating the Contract. Changes shall not be binding upon either IPSC or the Contractor unless made in writing in accordance with this Article.

   Changes will originate with the Chief Operations Officer who will transmit to the Contractor a written request for a Proposal covering the requested change, setting forth the work in detail, and including any required supplemental plans or specifications. Upon receipt of such request, the Contractor shall promptly submit in writing to the Chief Operations Officer a Proposal offering to perform such change, a request for any required extension of time caused by such change, and an itemized statement of the cost or credit for the proposed change. Failure of the Contractor to include a request for extension of time in the Proposal shall constitute conclusive evidence that such extra work or revisions will entail no delay and that no extension of time will be required.

   If the Contractor's Proposal is accepted by IPSC, a written change order will be issued by the Chief Operations Officer stating that the extra work or change is authorized and granting any required adjustments of Contract price and of time of completion.

   The performance of extra work or changes pursuant to the change order shall be in accordance with the terms and conditions of these specifications. No extra work shall be performed or change made unless pursuant to such written change order, and no claim for an addition to the Contract price shall be valid unless so ordered.

10. Changes at Request of Contractor: Changes may be made to facilitate the work of the Contractor. Such changes may only be made without additional cost to IPSC and without extension of time. Permission for such changes shall be requested in writing by the Contractor to the Chief Operations Officer.

11. Time is of the Essence and Extensions of Time: Time is of the essence of the Contract. Delivery shall be completed within the times and by the dates specified. Time for delivery shall not be extended except as provided in this Article.

    If the Contractor makes a timely written request in accordance with this Article, the time for delivery will be extended by a period of time equivalent to any delay of the whole work which is: (1) authorized in writing by the Chief Operations Officer, (2) caused solely by IPSC, or (3) due to unforeseeable causes (such as war, strikes, or natural disasters) and which delay is beyond the control and without the fault or negligence of the Contractor and subcontractors.

    The Contractor shall promptly notify the Chief Operations Officer in writing at both the beginning and ending of any delay, of its cause, its effect on the whole work, and the extension of time claimed. Failure of the Contractor to provide such written notices and to show such facts shall constitute conclusive evidence that no excusable delay has occurred and that no extension of time is required.

    The Chief Operations Officer will ascertain the facts and the extent of the delay and will extend the time for delivery when the findings of fact justify such an extension. The Chief Operations Officer's determination will be final and conclusive.

    IPSC will be responsible for extensions of time as herein provided, but will not otherwise be responsible in any manner or to any extent for damage directly or indirectly suffered by the Contractor by any delay.

12. Protests and Claims: If the Contractor considers any demand of the Chief Operations Officer to be outside of the requirements of the Contract, or considers any amount of payment, or any record, ruling, or other act or omission by the Chief Operations Officer to be unreasonable, the Contractor shall promptly deliver to the Chief Operations Officer a written statement of the protest and of the amount of compensation claimed.

    Upon written request by the Chief Operations Officer, the Contractor shall provide access to all records containing any evidence relating to the claim or protest.

    Upon review of the protest, claim, and evidence, the Chief Operations Officer will promptly advise the Contractor in writing of the final decision which will be binding on all parties.

    The requirements of this Article shall be in addition to, and shall not be construed as waiving, claims provisions of the Government Code of the state of Utah. The Contractor is deemed to have waived and does waive all claims for extensions of time and for compensation in addition to the Contract price except for protests and claims made and determined in accordance with this Article.

13. Limitation of Liability: It is understood and agreed that IPA shall be the party solely liable to the Contractor for payments under this Contract and for any breaches, defaults, or for any torts in the performance of or in relation to this Contract by IPA or the Operating Agent or IPSC or any officers, agents, or employees thereof, and the Contractor hereby expressly covenants and agrees that no suit shall be brought by the

Contractor against the Operating Agent or IPSC or their officers, agents, or employees or any of the purchasers of power from IPA, but that all rights or remedies that the Contractor may have or that may arise shall be asserted by the Contractor solely against IPA.

14. Independent Contractor: The Contractor shall perform said services as an independent contractor in the pursuit of its independent calling, is not an employee, agent, joint venturer, partner, or other representative of IPA, IPSC or the Operating Agent and shall be under the control of IPSC only to provide the services requested and not as to the means or manner by which the work is to be accomplished. The Contractor has no authority to act for, bind, or legally commit IPA, IPSC, or the Operating Agent in any way.

15. Drug Policy: The Contractor shall submit a current copy of its drug policy for review. IPP facilities are a drug free and zero tolerance workplace. The Contractor and its subcontractors' employees who are to perform work at the IPP site shall participate in a drug testing program prior to arrival, and at any additional time(s) during the Contract as IPSC may request.

16. Nonexclusive: This is a nonexclusive Contract. IPSC reserves the right to obtain services from other Contractors.

PART E - DIVISION E2

ADDITIONAL GENERAL CONDITIONS

1. Payment: Payment will be made within thirty (30) calendar days after delivery and receipt of the invoice.

2. Additional Work Invoices: Invoices for materials or labor outside of the base scope of work shall be submitted to the Contract Administrator. Each invoice shall show the Contract number in addition to the essential information on each delivery covered by the invoice. In all cases, the amount of the applicable sales tax or use tax shall be separately stated on the invoice.

3. Regulations, Permits, Licenses, and Warrants: The Contractor shall comply with all applicable federal, state, and local regulations including, but not limited to, Federal and State OSHA, as said regulations relate to this Contract. In addition, the Contractor shall ensure that all permits, licenses, and warrants relating to the Contract be acquired.

4. Letters to IPSC: All inquiries relating to these specifications prior to award of the Contract shall be addressed to the Buyer.

   All letters pertaining to invoices shall be addressed in accordance with Article 3 of this Division.

   After award of Contract, all letters pertaining to performance of the Contract shall be addressed as follows:

   George W. Cross
   President and Chief Operations Officer
   Intermountain Power Service Corporation
   850 West Brush Wellman Road
   Delta, UT 84624-9546

   Attention: Contract Administrator

   Regarding Contract No: **02-XXXXX**

PART F - DIVISION F1

DETAILED SPECIFICATIONS - SPECIAL CONDITIONS

1. General: Under the terms of the Contract, the Contractor shall furnish and deliver manpower and material as needed by IPSC during the Contract period beginning with date of award of the Contract, hereinafter called the "Contractual Period."

2. Printed Documents: All printed documents including drawings and instruction books, if applicable, shall be in the English language. All units of measurement shall be in the English foot-pound-second system.

3. Indemnity Clause: The Contractor undertakes and agrees to indemnify, hold harmless, and at the option of the Intermountain Power Agency, defend Intermountain Power Agency, Intermountain Power Service Corporation, Los Angeles Department of Water and Power, and any and all of their boards, officers, agents, representatives, employees, assigns and successors in interest from and against any and all suits and causes of action, claims, charges, costs, damages, demands, expenses (including, but not limited to, reasonable attorneys' fees and cost of litigation), judgments, civil fines and penalties, liabilities or losses of any kind or nature, including, but not limited to, violations of regulatory law, death, bodily injury or personal injury to any person, including the Contractor's employees and agents, or damage or destruction to any property of either party hereto, or third persons arising out of the work of the Contractor, or resulting from any negligent act or omission of the Contractor, or anyone directly or indirectly employed by the Contractor, or the Contractor's officers, agents, employees, or subcontractors of any tier, except for the sole negligence of IPA, IPSC, LADWP, or their boards, officers, agents, representatives, or employees.

4. Insurance Requirements: Prior to the start of work, but not later than thirty (30) days after date of the award of Contract, the Contractor shall furnish IPSC evidence of coverage from insurers acceptable to IPSC and in a form acceptable to the Insurance Analyst for IPSC. Such insurance shall be maintained by the Contractor and at the Contractor's sole cost and expense.

   Such insurance shall be provided for the obligations of the Contractor assumed under the Contract. IPA, IPSC, or LADWP will not, by reason of its inclusion under these policies, incur liability to the insurance carrier for payment of premium for these policies.

   Any insurance carried by IPA, IPSC, or LADWP which may be applicable will be deemed to be excess insurance and the Contractor's insurance is primary for all purposes despite any conflicting provision in the Contractor's policies to the contrary.

   Should any portion of the required insurance be on a "Claims Made" policy, the Contractor shall, at the policy expiration date following completion of the work, provide evidence that the "Claims Made" policy has been renewed or replaced with the same limits and terms and conditions of the expiring policy, or that an extended discovery period has been purchased on the expiring policy at least for the Contract under which the work was performed.

   Failure to maintain and provide acceptable evidence of the required insurance for the required period of coverage shall constitute a breach of Contract, upon which the Contract may be terminated or suspended.

a. Workers' Compensation/Employer's Liability

Workers' Compensation Insurance covering all of the Contractor's employees in accordance with the laws of any state in which the work is to be performed and including Employer's Liability Insurance, and as appropriate, Broad Form All States Endorsement, Voluntary Compensation, Longshoremen's and Harbor Workers' Compensation, Jones Act, and Outer-Continental Shelf coverages. The limit for Employer's Liability coverage shall be not less than $1 million each accident and shall be a separate policy if not included with Workers' Compensation coverage. Evidence of such insurance shall be an endorsement to the policy providing for a thirty (30) day prior written notice of cancellation or nonrenewal of a continuous policy to IPSC, by receipted delivery, and a Waiver of Subrogation in favor of IPSC, IPA, and LADWP, its officers, agents, and employees. Workers' Compensation/Employer's Liability exposure may be self-insured provided that IPSC is furnished with a copy of the certificate issued by the state authorizing the Contractor to self-insure. The Contractor shall notify IPSC, by receipted delivery, as soon as possible of the state withdrawing authority to self-insure.

b. Commercial General Liability

Commercial General Liability with Blanket Contractual Liability, Products and Completed Operations, Broad Form Property Damage, Premises and Operations, Independent Contractors, and Personal Injury coverages included. Such insurance shall provide coverage for total limits actually arranged by the Contractor, but not less than $5 million Combined Single Limit and be specific for this Contract. Umbrella or Excess Liability coverages may be used to supplement primary coverages to meet the required limits. Evidence of such coverages shall be on IPSC's Additional Insured Endorsement Form or on an endorsement to the policy acceptable to IPSC and provide for the following:

(1) To include IPA, IPSC, LADWP, and their officers, agents, and employees as additional insured with the Named Insured for the activities and operations under the Contract.

(2) That the insurance is primary and not contributing with any other insurance maintained by IPA, IPSC, or LADWP.

(3) A Severability-of-Interest of Cross-Liability Clause such as: "The policy to which this endorsement is attached shall apply separately to each insured against whom a claim is made or suit is brought, except with respect to the limits of the company's liability."

(4) That the policy shall not be subject to cancellation except after written notice to IPSC, by receipted delivery, not less than thirty (30) days prior to the effective date thereof.

(5) A description of the coverages included under the policy as required by the Contract.

c. Commercial Automobile Liability

Commercial Automobile Liability covering the use of owned, nonowned, hired, and leased vehicles for total limits actually arranged by the Contractor, but not less than $1 million Combined Single Limit. Such insurance shall include Contractual Liability coverage. The method of providing evidence of insurance and requirements for additional insureds, primary insurance, notice of cancellation, and Severability-of-Interest shall be the same as required in the Commercial General Liability Section of these terms and conditions.

d. Professional Liability

The Engineer shall provide Professional Liability Insurance with Contractual Liability coverage included, covering the contractor's liability arising from errors and omissions made directly or indirectly during the execution of this contract and shall provide coverage for the total limits actually arranged by the contractor, but not less than $5 million, Combined Single Limit. Such policy shall be maintained for not less than three (3) years after the date of final acceptance and completion of the work performed under this contract. Evidence of such insurance shall be in the form of a special endorsement of insurance and shall include a Waiver of Subrogration against the Intermountain Power Agency, the Intermountain Power Service Corporation and the Los Angeles Department of Water and Power, and their officer, agents and employees.

e. Other Conditions.

(1) Failure to maintain and provide acceptable evidence of the required insurance for the required period of coverage shall constitute a major breach of Contract, upon which IPSC may immediately terminate or suspend the Agreement, or at its option, procure such insurance and submit a claim against Contractor's Performance Bond, deduct the cost thereof, including an administrative charge of two (2) percent, from any monies due the Contractor, or shall be immediately reimbursed by the Contractor for such costs upon demand.

(2) The Contractor shall be responsible for all subcontractors compliance with these insurance requirements.

5. Transportation: All shipments of hazardous materials under this Contract shall be handled in accordance with current U.S. Department of Transportation regulations and other applicable federal, state, and local laws and regulations.

6. Safety: The Contractor agrees it is familiar with the risks of injury associated with the work, has reviewed the work to be performed, inspected the job site with an IPSC

representative, and has determined that no unusual or peculiar risk of harm exists with regard to the work to be performed at the job site.

The Contractor further agrees it shall, at all times, provide at the job site a competent supervisor(s) familiar with IPSC's and the industry's safety standards to ensure compliance with all federal, state, and local regulations pertaining to safety, including, but not limited to, Federal and State OSHA, as said regulations relate to the work to be performed under the Contract. Although IPSC assumes no responsibility to oversee or supervise the work, IPSC reserves the right to review safety programs and practices and make recommendations to the Contractor. Any such review or recommendation by IPSC will not increase IPSC's liability or responsibility and shall not relieve the Contractor from providing a safe work environment and complying with legal requirements.

The Contractor shall comply with IPSC's safety and equipment requirements prior to starting work. Worker protective clothing, which includes, but is not limited to, hardhats, safety glasses, safety shoes, gloves, respirators, earplugs, safety harnesses, and face shields shall be provided by the Contractor.

Prior to starting work, all of the Contractor's personnel shall attend a safety orientation taught by a representative of IPSC. At the Contractor's option, a supervisor may attend the orientation taught by IPSC, then present the orientation to the remainder of the Contractor's personnel. In this case, a roll shall be given to IPSC which lists each person who received the orientation and the date it was received.

7. Security Compliance: The Contractor and its employees, agents, representatives, and/or subcontractors, while performing work or services on IPSC premises, shall fully comply with all fire prevention, security, and safety rules in force at IPSC. The Contractor and its employees, agents, representatives, and/or subcontractors personnel and vehicles are subject to a random inspection of his/her person and/or vehicle upon entering, working on, and departing the plant site.

   The Contractor will be directed to specified areas for parking vehicles and equipment by the Contract Administrator. Certain areas of the IPSC plant site are restricted to IPSC vehicles only. Exceptions to the parking restriction will be made on an as needed basis through the Contractor's respective Contract Administrator. The Contractor shall make its employees, agents, representatives, and/or subcontractors aware of all areas that are subject to restricted parking.

8. Material Safety Data Sheets: The Contractor shall furnish a Material Safety Data Sheet (MSDS) for all hazardous materials furnished under this Contract. The MSDS shall be furnished to IPSC on, or prior to, the date of the first delivery of the materials or equipment.

   If the specifications require that the Contractor furnish instruction books, the Material Safety Data Sheets shall also be included in such books.

9. Liquidated Damages: The Contractor shall be penalized for substandard performance, in delivery and installation, in accordance with the following provisions:

a. If the Contractor is not prepared to proceed with the approved Installation Plan at the start of each respective outage, the Contractor shall pay for all costs associated with mobilization and demobilization incurred by the Contractor plus a boiler performance penalty of $100,000, representing a small fraction of the cost incurred by the Owner.

b. For each day, at the start of each respective outage, that the Contractor is unprepared to execute the approved Installation/Removal Plan, the Contractor shall be assessed a penalty of $100,000.00, up to a maximum of 10 days or $1,000,000.00 .

c. For each day or portion thereof, that the Contractor exceeds the 'Boiler Released to Operations' date specified in the contract Installation Plan, the Contractor shall be penalized $100,000.00. The maximum penalty for extending a single unit outage shall be 10 days or $1,000,000.

d. The Contractor shall be allowed to avoid one day of penalty associated with exceeding the 'Boiler Released to Operations' date, should such occur, if all materials and equipment are received and staged at the site in accordance with the approved Installation Plan, at least one week prior to the outage start date.

10. Contract Termination: IPSC reserves the right, by giving written notice to the Contractor, to terminate the whole or any part of this Contract at IPSC's convenience, whether or not the Contractor is in default. In the event of termination, IPA will pay the Contractor reasonable and proper termination costs; however, if the Contractor's Proposal includes cancellation charges, payment for termination costs shall not exceed the cancellation charges set forth therein. Termination of the work shall not constitute the basis for a claim for damages or loss of anticipated profits and the Contractor hereby releases IPA, IPSC, and LADWP from any such claim.

The Contractor shall, after consultation with IPSC, take all reasonable steps to minimize the costs related to termination. The Contractor shall provide IPSC with an accounting of costs claimed, including adequate supporting information and documentation and IPSC may, at its expense, audit the claimed costs and supporting information and documentation.

11. Typical Site Weather Conditions:
The average daily temperature at the plant site is 90°F in summer and 45°F in winter. During winter it is common for the temperature to stay below 10°F for up to two (2) weeks. Winter snow is a common occurrence and can stay on the ground for extended periods. The boilers are located indoors but are open to ambient conditions during outages. The Contractor shall come prepared for temperature extremes.

PART F - DETAILED SPECIFICATIONS

DIVISION F2 - DETAILED REQUIREMENTS

1. General: The scope of this contract includes the design, installation, and removal of Boiler Scaffolding for Intermountain Generating Station (IGS) Units 1 & 2.

2. Project Scope: The Contractor shall design, furnish and install a multi-level access scaffolding system for installation in the boiler furnace in 4 days or less. Removal of the scaffold from the boiler shall occur in 3 days or less.

   The scaffold system shall be designed to allow access for work on all burner levels, OFA port installation, general inspection and repair of possible eroded areas around all wall blowers and full platform access at the arch nose elevation. This includes 4', full perimeter walkway access at eight separate levels and a full platform at the arch nose elevation.

   Above the nose platform, scaffold shall be provided for full access to platen tube cut/weld line on both sides of each element. Scaffold shall be designed for convenient, standing access to all platen extension welds.

   Scaffold hardware shall also be provided for access to all approximate 250 split ring castings on the intermediate superheat pendants.

   All scaffold and access hardware shall be OSHA approved structures. The furnace scaffold structure shall be thoroughly reviewed and stamped by an experienced, professional, structural engineer licensed in the State of Utah.

   The Owner shall be allowed access to scaffold and other access provisions in any areas required. This work will be coordinated through the Contract Administrator or designee in a manner aimed at minimizing contractor schedule impacts. Scheduled Owner work within the areas of the contract work shall be outlined within the approved Installation Plan.

   The Contractor's proposal shall include allowable scaffold loading in live loads and dead loads. Any restrictions such as, maximum personnel per level or ratings for dynamic loads should be specified.

3. Schedules: The Unit 1 Outage is currently scheduled to begin on March 1, 2003 and end on March 28, 2003. The Unit 2 Outage is currently scheduled to begin on February 28, 2004 and end on March 26, 2004.

   a. All bidders shall provide a guaranteed installation schedule as part of the proposed Installation Plan submitted with each bid package.

   b. The proposed Installation Plan shall be developed to ensure completion of all erection work inside the boiler including sign-off from an IPSC Safety Specialist within a maximum of 96 hours. This 96 hour period shall begin on March 1, 2003 at 7:00 PM MST for Unit 1, and February 28, 2004 at 7:00 PM MST. Removal of the same scaffold structure is not to exceed 72 hours. Removal is to begin approximately 19 days after erection is complete.

c. Work not requiring the unit to be off-line, such as mobilization, staging, boiler enclosure structural access work, demobilization etc. shall be clearly identified on the proposed Installation Plan and can be coordinated outside this outage window, with approval of the Contract Administrator.

d. The bidders shall provide a schedule of costs associated with an IPSC scheduled delay of the outage start date in one week increments up to a one month. These costs shall be based on notification from IPSC 1 month prior to the scheduled outage start dates and a second schedule based on notification from IPSC 1 week prior to the scheduled outage start dates.

e. Unless otherwise noted in these Specifications, IPSC facilities and equipment shall not be used in support of this work. To prevent delays, caused by equipment breakdown, the Contractor shall provide spare tools and equipment at the jobsite in reasonable quantities in anticipation of equipment failures.

4. Installation : Each bidder shall prepare and provide, with each bid package, a proposed Installation Plan showing project progress on a daily basis beginning with initial equipment delivery and ending with site clean up and exit.

a. The proposed Installation Plan, submitted with the bid package, shall be the basis for development of the approved Installation Plan forming a part of the eventual contract governing this work. The approved Installation Plan shall be used as the basis for instituting mid-outage resource corrections and for calculating any penalties associated with completion of the work scope.

b. The proposed Installation Plan shall include detailed information regarding each task within the contract scope, including:

- Equipment and Material Delivery
- Equipment Mobilization and Assembly
- Manpower Loading Throughout the Contract
- Scaffold Installation Plan
    - Scaffold Erected - Guaranteed Schedule
    - Scaffold Removed - Guaranteed Schedule
- Boiler Released to Operations - Guaranteed Date
- Equipment Disassembly
- Material Equipment Removal and Area Clean-up

c. The proposed Installation Plan, to be included as part of the submitted bid, shall include estimates of all required on-site services, with clear identification of each request for service to be provided by IPSC. These estimates shall include power service requirements for running all electrical equipment and compressed air requirements. Authorization for connection to and use of requested power, compressed air or other on-site services must be coordinated and approved by the IPSC Contract Administrator.

d. At least two (2) months prior to mobilization to the site, the successful bidder shall provide a detailed material 'Laydown Plan' for coordination of area utilization and access. The Laydown Plan shall address staging and temporary storage requirements for all associated materials and equipment in order to minimize interference with ongoing plant operations and outage work. This plan shall be submitted to and approved by the Contract Administrator prior to receiving any contract materials, equipment or craft personnel on-site for the outage work.

5. Applicable Codes and Standards:

The work performed within these specifications shall adhere to the applicable portions of the latest published revision of the following codes and standards:

- OSHA Occupational Safety and Health Administration

6. Safety: The Contractor shall be responsible to provide and manage an acceptable safety program. For additional information see Division F1, Page F1-3, Article 6.

a. The Contractor shall ensure that its employees perform work in accordance with all applicable federal, state, and local safety and health regulations. The IPSC Safety Section personnel will periodically monitor the job site. If violations are noted, they will be reported to the Contractor's onsite Supervisor and the Contract Administrator for appropriate action. A safety incentive program will be implemented for the duration of the contract period. Each time a violation is noted, the contractor will pay IPSC the sum of $2,000. If no safety violations are noted through the completion of work, IPSC will pay the contractor $10,000.

b. The Contractor shall provide a full-time Safety Representative. The Safety Representative shall act as the point of contact for all safety-related issues and may be assigned additional duties.

c. The Contractor shall provide copies of written safety policies/plans to the Contract Administrator one (1) month prior to beginning work. These include, but are not limited to, Respiratory Protection, Confined Spaces, and Hazard Communication.

d. Prior to flame cutting or welding in any location, the Contractor shall first obtain a Hot Work Permit. This permit will be coordinated by the Contract Administrator or designee. The permit lists mandatory safety precautions which shall be taken before, during, and after hot work.

e. The following table is a list of anticipated safety hazards and personal protective equipment needed in the contract area. This must not be considered a complete listing of all potential hazards. The Contractor shall provide appropriate personal protective equipment to its employees to protect against these hazards and others as they are identified :

Hazard	Needed Safety Equipment
Hazardous noise.	Earplugs and/or muffs.
Head injuries from falling material or bumps.	Hard hats.
Foot injuries from dropped tools or equipment.	Steel-toed boots.
Eye and face injuries.	Safety glasses and face shields.

7. Available On-Site Services: Unless otherwise arranged, in writing, with the Contract Administrator, on-site services shall be provided in accordance with this section. Services not covered in this section shall be provided by the Contractor.

a. IPSC will make potable water, compressed air (small volume only), and electricity available at 460V and 120V. Connections to IPSC electric or water systems shall be made only by IPSC employees unless approved otherwise in writing for each specific location. The Contractor shall identify all service connection requirements within the proposed Installation Plan.

b. The Contractor shall provide enough sanitary facilities for its employees. Contractor employees are prohibited from using the permanent restroom facilities at the site.

c. Equipment and material staging requirements shall be clearly detailed within the successful bidders site Laydown Plan submitted to the Contract Administrator at least two months prior to the outage start date. Actual placement of materials and equipment shall be coordinated with the Contract Administrator.

d. The Contractor shall maintain a clean work space. The Contractor shall clean the work site at least daily. This includes, but is not limited to, picking up trash, sweeping, and washing the area as necessary, straightening cords and hoses, organizing tools and equipment, and emptying trash receptacles. IPSC will provide trash collection containers (dumpsters) for the Contractor's use, outside the generation building at ground level. IPSC will empty these containers as needed.

e. IPSC will provide general fire protection and first aid services. All workplace injuries shall be reported to the IPSC First Aid Clinic and the Contract Administrator.

g. IPSC will not provide office or administrative space or off-site telephone service to the Contractor; however, IPSC will make an on-site telephone line available to the Contractor at a specific, office-trailer-ready location, if requested. The Contractor shall make its own arrangements for "off-site" and long distance phone service.

8. Site Security and Access: The Intermountain Generating Station has an existing fence and security system to restrict access to the site. However, the construction site will not be fenced separate from the rest of the plant site and will therefore be accessible by all those approved for site access. It is the contractors responsibility to protect themselves and their equipment and tools from theft and vandalism as they deem necessary. IPSC will not be responsible for any theft or damage incurred by the contractor.

   a. Only vehicles owned and insured by the Contractor or an approved sub-contractor will be allowed inside the plant fence perimeter. All other contractor employees shall park their vehicles outside the fence perimeter at Guard Post #1 located southwest of Unit 2. The contractor shall be responsible for transport of the employees to and from Guard Post #1 and the jobsite. The contractor shall not use the back of trucks for employee transport.

   b. All contractor employees will be given security badges by the owner and those badges shall be displayed each day to gain admittance to the plant site. All security badges shall be returned to the security contractor when the employee terminates their work at this site. All contractor vehicles will also receive parking stickers from the security contractor allowing entrance to the plant site. Temporary badges and parking stickers are available for intermittent contractor employees and vehicles.

9. Shipping, Receiving, Handling and Storing:

   The contractor is responsible for own unloading, handling, and loading of materials and equipment. Materials and equipment shall not be stored in areas not approved by the Contract Administrator. Overhead cranes and freight elevators will be made available inside the generation building for material transportation.

   During staging inside the generation building, material shall not exceed a loading of 100 psf and shall not be stacked higher than 5 feet.

10. Schedule Guarantees: Significant weight will be applied to the form and type of the schedule guarantees offered within each bid.

a. Bid evaluation credit will be giving for each hour less than the 96 hour maximum erection limit at a rate of $2500 per hour and a maximum of $30,000.

b. If the contractor exceeds the installation guarantee time, IPSC shall fine the contractor $10,000. If the contractor exceeds the 96 hour limit, IPSC shall fine the contractor and additional $10,000. For every 12 hour shift the 96 hour limit is exceeded, IPSC shall fine the contractor an additional $10,000.

c. Bid evaluation credit will be giving for each hour less than the 72 hour maximum removal limit at a rate of $2500 per hour and a maximum of $30,000.

c. If the contractor exceeds the removal guarantee time, IPSC shall fine the contractor $10,000. If the contractor exceeds the 72 hour limit, IPSC shall fine the contractor and additional $10,000. For every 12 hour shift the 72 hour limit is exceeded, IPSC shall fine the contractor an additional $10,000.

INTERMOUNTAIN POWER SERVICES CORPORATION

DOCUMENTATION TRANSMITTAL FORM

TO: IGS02-14 file, w/ attachments

IPSC W.O. #02-60456-0 CAP. PROJ. #IGS02-14

TITLE: Boiler Modifications DATE: May 19, 2004

PREPARED BY: DEW

CAPITAL PROJECT REVIEW:

The following drawings have been placed in the master drawing file for future reference.

ITEM 1- CONSTRUCTION DRAWINGS

Dwg. No.	Rev. No.	DATE	Markup Print Size	Micflm Aperture Card	Comments

ITEM 2- MANUFACTURERS' DRAWINGS

Dwg. No.	Rev. No.	DATE	Markup Print Size	Micflm Aperture Card	Comments
62.3401.05-10870	2	7/1/97	11X17		

Field Alteration; Internals Steam Drum; Section 'A-A'; Notes and References

62.3401.05-10871	1	7/1/97	11X17

Field Alteration; Cyclone Steam Separators; Steam Drum Internals; Section 'B-B'

62.3401.05-10872	1	7/1/97	11X17

Field Alteration; Insturment Piping and End Caps; Steam Drum Internals; Section 'C-C'

62.3401.05-10873	1	7/1/97	11X17

Field Alteration; Deflector Baffle; Steam Drum Internals; Section 'D-D'

62.3401.05-10874	1	7/1/97	11X17

Field Alteration; Deflector Baffle; Steam Drum Internals; Sections and Views

62.3401.05-108751	00	7/1/97	11X17

Field Weld & NDE Schedule; Non-pressure to Pressure.

ITEM 3 - INSTRUCTION MANUALS

Instr. Man/Section/Page	Directions and Comments

ITEM 4 - SYSTEM DESCRIPTIONS (INCLUDES TEXT, MARKED UP SKETCHES, E1000, M1000 DRAWINGS AND 11x17 COPY OF P&IDS).

System Code	System Title/Page	Comments

ITEM 5 - POWRTRAK REVISIONS

Device No.	New/ Revised/ Deleted	Screen Prints	Comments

ITEM 6- LOVELAND REVISIONS
ASSOCIATED DOCUMENTATION FOR WHICH IPSC IS RESPONSIBLE:
(NOT TRANSMITTED)

Device No.	New/ Revised/ Deleted	Screen Prints	Comments

ITEM 7- TAYLOR SOFTWARE REVISIONS

System Code and Title	New/Revised Network	Comments

ITEM 8- RELAY MANUAL UPDATES

Manual and Page	Relay #	Comments

ITEM 9- MISCELLANEOUS

INTERMOUNTAIN POWER SERVICE CORPORATION

☒ REQUISITION FOR CAPITAL EQUIPMENT

☐ PURCHASE AUTHORIZATION FOR EXPENSE ITEMS

Purpose of Materials, Supplies or Services:

Design and materials for Steam Drum Level Indicator modifications for Unit 2.

Date:	
Req./PA No:	190842
P.O. No:	
Vendor:	
Terms:	
FOB:	
Ship Via:	
Conf. To:	

Suggested Vendor: Babcock & Wilcox
3535 s. Platte River Drive; Unit G-3
Sheridan, CO 80110

Account No. 00-2SGX-402
Work Order No. 02-60456-0
Project No.

Qty	Unit	Description: Noun / Adjective / Catalog # / Seller or Manufacturer	Unit Cost	Extension
1	Lot	Materials and documentation for Unit 2 steam drum	$13,950.00	$13,950.00
		internal modifications per B&W Proposal P-4572		
		dated August 5, 2003.		
		TOTAL ESTIMATED COST		$13,950.00

Remarks: B&W's proposal (attached) includes 8 pages of Terms and Conditions. I am leaving it to Purchasing to ensure that these are acceptable to IPSC.

Delivery requested by [Date] 11-30-03 Originator Dean E. Wood

Dept. Mgr/Supt. Date Station Manager Date Operating Agent Date

IP7_037332

18 OCT 2002 03-45576 7792 181199
REVISED 17 AUG 2005

BABCOCK BORSIG POWER
PO BOX 15040
5 NEPONSET ST (01606)
WORCESTER, MA 01615-0040
508-852-7100

* * * S H I P T O * * *
INTERMOUNTAIN POWER SERVICE CORPORATION
850 W. BRUSH WELLMAN RD.
DELTA , UT 84624-9546

X N/A AS INVOICED NONE 1 1 MAIL

THIS IS A PURCHASE ORDER ADJUSTMENT

LINE 1 ** PRICE CHANGED
0 EA DESIGN, SUPPLY, AND INSTALL: BOILER 1SGX-402 8,689,769.00 0.00
UPRATE MODIFICATIONS ON UNIT 1 AND UNIT 2 02-60456-0

**PER REQUISITION 189809, INCREASE CONTRACT
AMOUNT BY $60,000; FOR TEI CONSTRUCTION TO
PROVIDE ALL LABOR, TOOLS, EQUIPMENT, AND
WELDING SUPPORT FOR BURNER INSPECTION
REPAIRS REQUIRED DURING UNIT 1, 2003 OUTAGE**
RCN/CLE

**PER REQUISITION 214873, INCREASE CONTRACT
AMOUNT BY $100,000 FOR EARLY-COMPLETION
INCENTIVE; APPROVED BY LADWP 7/29/05;
TOTAL AMOUNT OF CONTRACT IS $8,689,769**
RCN/CLE 8/17/05

RALPH NEWBERRY 435-864-4414

REVIEWED BY GEORGE CROSS

IP7_037333